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M 55-15

Reference

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FM 55-15**DEPARTMENT OF THE ARMY FIELD MANUAL**

TRANSPORTATION REFERENCE DATA



**HEADQUARTERS, DEPARTMENT OF THE ARMY
DECEMBER 1963**

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1. *Chlorophyll a* and *Chlorophyll b* were determined by the method of Lichtenthaler and Whistler (1973). The total chlorophyll content was determined by the method of Arar and Cook (1980). The carotenoid content was determined by the method of Lichtenthaler and Whistler (1973). The total carotenoid content was determined by the method of Arar and Cook (1980). The total protein content was determined by the method of Lowry et al. (1951). The total lipid content was determined by the method of Bligh and Dyer (1959). The total carbohydrate content was determined by the method of Dubois and Gilles (1950). The total nucleic acid content was determined by the method of Burton (1956). The total ash content was determined by the method of AOAC (1990). The total moisture content was determined by the method of AOAC (1990). The total dry matter content was determined by the method of AOAC (1990). The total organic acid content was determined by the method of AOAC (1990). The total alkaloid content was determined by the method of AOAC (1990). The total flavonoid content was determined by the method of AOAC (1990). The total phenol content was determined by the method of AOAC (1990). The total tannin content was determined by the method of AOAC (1990). The total saponin content was determined by the method of AOAC (1990). The total sterol content was determined by the method of AOAC (1990). The total glycoside content was determined by the method of AOAC (1990). The total alkaloid content was determined by the method of AOAC (1990). The total flavonoid content was determined by the method of AOAC (1990). The total phenol content was determined by the method of AOAC (1990). The total tannin content was determined by the method of AOAC (1990). The total saponin content was determined by the method of AOAC (1990). The total sterol content was determined by the method of AOAC (1990). The total glycoside content was determined by the method of AOAC (1990).

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FIELD MANUAL
No. 55-15

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 31 December 1963

TRANSPORTATION REFERENCE DATA

	Paragraphs	Page
CHAPTER 1. GENERAL.....	1.1-1.3	2
2. AIR.....		
Section I. Organization.....	2.1	3
II. Aircraft.....	2.2-2.6	4
III. Operations.....	2.7-2.23	33
IV. Maintenance and supply.....	2.24-2.27	40
CHAPTER 3. MOTOR.....		
Section I. Organization.....	3.1	42
II. Vehicles and equipment.....	3.2, 3.3	44
III. Operations.....	3.4-3.38	51
IV. Maintenance and supply.....	3.39-3.42	109
V. Miscellaneous.....	3.43-3.50	115
CHAPTER 4. RAIL.....		
Section I. Organization.....	4.1	124
II. Equipment.....	4.2-4.5	126
III. Operations.....	4.6-4.22	131
IV. Construction, maintenance, and supply.....	4.23-4.35	164
CHAPTER 5. TERMINAL AND WATER TRANSPORT.....		
Section I. Terminal organization.....	5.1, 5.2	170
II. Vessel characteristics and data.....	5.3-5.21	173
III. Terminal and water transport operations.....	5.22-5.39	199
IV. Hoisting and conveying data.....	5.40-5.51	225
V. Terms.....	5.52-5.55	233
VI. Miscellaneous.....	5.56-5.59	237
CHAPTER 6. PLANNING.....		
Section I. Orders and standing operating procedures.....	6.1-6.7	242
II. Intelligence.....	6.8, 6.9	254
III. Transportation estimate and plan.....	6.10-6.12	255
CHAPTER 7. MISCELLANEOUS.....		
Section I. Capabilities of transportation mediums.....	7.1-7.3	261
II. Dimensions and weight data.....	7.4-7.8	262
III. Cold weather data.....	7.9-7.13	279
IV. Cargo containers, pallets, and marking.....	7.14-7.18	285
V. Communications.....	7.19-7.22	290
VI. First aid and CBR and nuclear weapons defensive and protective measures.....	7.23-7.26	295
VII. POL containers and pipelines.....	7.27-7.30	311
VIII. Supply.....	7.31-7.37	324
IX. Storage and maintenance space.....	7.38, 7.39	329
X. Field establishments and expedients.....	7.40-7.46	329
XI. Conversion factors.....	7.47-7.53	339
XII. Stowage factors.....	7.54-7.57	351
XIII. Mathematical tables and formulas.....	7.58-7.63	357
XIV. Time, tide, and light.....	7.64-7.67	363
XV. Terrain factors.....	7.68, 7.69	370
XVI. Air transportability.....	7.70-7.72	373
APPENDIX I. REFERENCES.....		385
II. ABBREVIATIONS.....		390
III. MAP SYMBOLS.....		397
INDEX.....		408

* This manual supersedes FM 55-15, 15 July 1960, and FM 55-54, 19 June 1959.

CHAPTER 1

GENERAL

1.1 Purpose and Scope

a. This manual is both a planning guide for staff and unit officers and a digest of operational data for use as a reference by operators and users of transportation when unit or staff libraries are not readily available.

b. This manual includes characteristics of typical transportation equipment and facilities and methods for estimating the capabilities of, or requirements for, transportation equipment, facilities, and troop units. Personnel and equipment data for the modes of transportation and for transportation terminals are presented as well as data for computing requirements for staff, supervisory, and control activities. Factors concerning administrative support requirements are included. It also contains report formats and examples of orders and standing operating procedures. Loading data for water, rail, motor, and air movements;

tables on weights, measures, and conversion factors; and miscellaneous data of general usefulness are included.

1.2 Application

The material presented herein is applicable to nuclear and non-nuclear warfare.

1.3 Changes and Revision

Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded direct to the Commandant, U.S. Army Transportation School, Fort Eustis, Virginia.

CHAPTER 2

AIR

Section I. ORGANIZATION

2.1 Organization

<i>Unit</i>	<i>TOE</i>	<i>Mission and/or capability</i>	<i>Assignment</i>
Headquarters and headquarters detachment, transportation transport aircraft battalion.	55-56	To provide command control, staff planning, and administrative supervision for 2 to 7 transport aircraft companies.	To a field army.
Transportation light helicopter company.	55-57	To expedite combat operations by providing direct tactical and logistical air transport support to combat units.	To a field army, normally 3 per transport aircraft battalion.
Transportation medium helicopter company.	55-58	To provide air transport to expedite tactical operations and logistical support in the combat zone. At maximum, it can move 48 tons of cargo or 368 troops within 100-mile radius in 1 lift.	To a field army, normally 1 per transport aircraft battalion.
Transportation medium airplane company.	-----	To provide logistical airlift for movement of supplies and personnel in the combat zone and, as directed, to provide tactical airlift of combat units and air resupply of units engaged in combat operations.	To a field army, normally attached to headquarters and headquarters detachment, transportation battalion (TOE 55-56).
Headquarters and headquarters detachment, transportation aircraft maintenance and supply battalion.	55-456	To provide command control, staff planning and administrative supervision of assigned or attached transportation aircraft direct support companies, transportation transport aircraft support companies, transportation aircraft general support companies, and transportation aircraft maintenance teams.	To a field army or communications zone, normally 1 per 3-7 aircraft maintenance and supply companies.
Transportation aircraft direct support company.	55-457	To provide backup third-echelon aircraft maintenance and supply and recovery support to divisional aviation units, and to provide direct third-echelon maintenance and supply support to nondivisional aircraft units, other than transport aircraft units, in corps and army.	Normally to a corps or field army, in sufficient number to provide the direct support mission.
Transportation Army aircraft heavy maintenance and supply company.	55-458	To provide heavy maintenance and supply support for Army aircraft in a field army.	Normally to a field army, in sufficient number to provide the general support mission.
Transportation transport aircraft direct support company.	55-468	To provide third-echelon field maintenance and supply and recovery support for light transport airplanes and medium transport helicopters assigned a transport aircraft battalion.	To a field army, normally attached to unit under TOE 55-456.
Transportation light transport helicopter direct support	55-469	To provide third-echelon field maintenance and supply and recovery	To a field army, normally attached to unit under

<i>Unit</i>	<i>TOE</i>	<i>Mission and/or capability</i>	<i>Assignment</i>
maintenance and supply company.		support for light transport helicopters assigned to a transport aircraft battalion.	TOE 55-456. May operate separately providing third-echelon maintenance support to 3 light transport helicopter companies or equivalent.
ROCID:			
Transportation aircraft Maintenance detachment (infantry or armored division).	55-79	To provide a third-echelon aircraft maintenance capability as an integral part of the infantry or armored division.	Organic to the division and attached to the infantry or armored division aviation company (1 per division).
ROAD:			
Transportation aircraft maintenance company, armored, infantry, or mechanized division maintenance battalion.	55-89	To provide third-echelon aircraft capability as an integral part of the support command of the armored, mechanized, or infantry division.	Organic to the infantry division maintenance battalion (TOE 29-15), mechanized division maintenance battalion (TOE 29-25), or armored division maintenance (TOE 29-35).
Transportation aircraft maintenance company, airborne division maintenance battalion.	55-99	To provide third-echelon aircraft maintenance capability as an integral part of the support command of the airborne division.	Organic to airborne division maintenance battalion (TOE 29-55).
Transportation helicopter teams and aircraft field maintenance teams.*	55-500 and 55-510	To provide personnel and equipment to supplement TOE units where additional trained personnel are required in numbers less than TOE strength, to perform transportation functions as part of a larger unit where the need for the activity is less than a similar TOE unit, and to operate as a separate organization where no TOE unit is provided.	Teams may be attached or assigned to higher echelon units or may be organized into service units to perform functions as required by existing conditions.

* See TOE's 55-500 and 55-510 for additional teams.

Section II. AIRCRAFT

2.2 Army Aircraft

a. Mission Planning. All planning beyond the preliminary stage should be coordinated with, or accomplished by, the aviation officer, the local operations officer, and the aviator designated to fly the mission. Some variables which are not discussed below but which must be considered in planning each mission are the proficiency of aviators and other operating and maintenance personnel, the effects of cargo loading and fuel burn-off on the center of gravity (CG) of the aircraft, mechanical condition of the aircraft, condition of runways, approaches to airfields, and navigation aids available for instrument approaches and landings during bad-weather operations. The conditions and criteria set forth in this manual are useful only for preliminary or general planning; they cannot and must not be used for specific mission planning.

b. Variables Affecting Performance. Some of the common variables affecting the performance standards of aircraft are discussed below.

- (1) *Air density and temperature.* The ability of the aircraft to lift weight is directly proportional to the density of the air mass in which it is operating; the density of the air mass is affected by, and is inversely proportional to, the temperature, humidity, and altitude above sea level. For example, the CV-2 (Caribou), weighing 26,000 pounds and operating from a point at sea level where the temperature is 59° F. (15° C.), requires 1,100 feet from the start of its takeoff run to clear a 50-foot obstacle. The same aircraft, operating at the same weight from an airport 5,000 feet above sea level where the temperature is 95° F. (35° C.), requires over 2,500

feet to clear a 50-foot obstacle. The capability of a helicopter with an externally slung load can be reduced as much as 80 percent between sea level at 0° F. and 6,000 feet at 95° F.

- (2) *Range and payload.* Range and payload capabilities outlined in this chapter are based on a sea-level takeoff in a standard atmosphere as defined by the International Civil Aeronautics Organization. The ICAO defines standard atmosphere as a dry air condition of 29.92 inches of mercury (Hg) pressure and 59° F. (15° C.) temperature.
- (3) *Wind.* Surface wind affects both fixed-wing and rotary-wing aircraft. In computations in this manual, the surface-wind velocity is assumed to be zero or negligible. If utilized in conjunction with available runways, a surface wind has a pronounced beneficial effect on the takeoff and landing characteristics of an aircraft, since lift capability is directly proportional to the speed of the air past the lifting surfaces.
- (4) *Speed.* Within the range of speeds in which a particular aircraft can fly, it can be said generally (except for turbine-powered aircraft) that the slower the speed, the longer the range for available fuel. A fixed-wing aircraft flying about 20 percent faster than its minimum speed can fly further than it can at its maximum speed. The tables and graphs in this chapter are based on normal cruise speed (the speed at which an aircraft is usually operated and which does not cause undue strain on the engine or excessive fuel consumption). For example, the CV-2 at its heaviest weight can fly at 5,000 feet using a horsepower range between 300 and 1,200 from each engine. The tables for this aircraft were computed at 600 horsepower for each engine, as this is the best compromise for good speed with minimum engine wear and fuel consumption. This same principle applies in a general sense to helicopters. However, since helicopters have no minimum forward speed, the best range is usually determined as some percentage of the maximum forward speed.

- (5) *Altitude.* The amount of oxygen available in the air decreases as altitude increases. Flight above 10,000 feet for an extended period is extremely dangerous unless personnel are supplied with oxygen or unless the aircraft is pressurized so that the atmosphere within corresponds to a lower level. Since there are no pressurized Army aircraft, oxygen supplies are needed for flights at altitudes over 10,000 feet. A minimum of 1,000 feet should be allowed for clearing obstacles; therefore, when the terrain altitude is over 9,000 feet, only aircraft supplied with oxygen should be programmed for flight. While oxygen supplies for the crew permit cargo flights above 10,000 feet, troop transport for extended periods is impractical without other provisions for oxygen.

- (6) *Weather.* For weather to permit VFR (visual flight rules) flight, the underside of the cloud ceiling should be at least 1,000 feet above the terrain for the entire route, and the visibility should be at least 3 miles in control zones around airfields and 1 mile outside control zones. All other weather is referred to as IFR (instrument flight rules). VFR aircraft cannot normally be flown in IFR weather. Of the Army IFR aircraft, only three (U-8, CV-2, and OV-1) have all-weather capability. These are equipped with anti-icing and deicing equipment in addition to other equipment for IFR conditions. However, the availability of all-weather aircraft and qualified aviators does not always guarantee the start of a mission; an aviator may very well have to refuse to attempt a mission if extreme weather is anticipated. If air turbulence or other conditions are such that an aircraft cannot remain airborne, it is foolhardy to attempt a mission. The high speed and long range of modern aircraft require adequate weather intelligence for the entire route before the start of any mission. The weather to be encountered en route may not, and very frequently is not, apparent at the originating point.

c. *Powerplants and Accessories.* Powerplants used in Army aircraft are of several different

types. As technological advances are made, it can be expected that powerplants and accessories other than those discussed below will be added to the inventory.

(1) *Engine types.*

- (a) *Turbo-jet.* This is a turbine-type engine which utilizes the thrust of its exhaust gases for propulsive power. This engine is not currently used in any Army aircraft.
- (b) *Turbo-shaft.* This engine is a double-turbine type which utilizes the thrust of its exhaust gases to drive a second or power turbine. The energy imparted to the power turbine is, in turn, transferred to a rotating shaft. This type of engine is used in Army helicopters to drive the rotors through gear reductions.
- (c) *Turbo-prop.* This engine is identical in principle to the turbo-shaft engine, but the power is imparted to a propeller through a gear reduction.
- (d) *Reciprocating.* This is a conventional engine having aircraft, automobile, and marine applications. Aircraft reciprocating engines are divided into several types and classes. The type is determined by the engine's shape and cylinder arrangement. The two classes are air cooled and liquid cooled. At present, Army aircraft do not use liquid-cooled engines. The types of reciprocating air-cooled engines used in Army aircraft are:

- 1. *Opposed.* The cylinders are arranged in two rows opposite each other. In fixed-wing aircraft, the engine is usually mounted so that the length of the cylinder is parallel to the ground. All opposed engines used in Army aircraft have six cylinders.
- 2. *Radial.* The cylinders are arranged radially around a central crankshaft. These engines are classified as single-bank or multibank. Single-bank engines always have an odd number of cylinders. Multibank engines are essentially two single-bank engines mounted back-to-back on a common crankshaft. Army aircraft employ both types of radial engines.

3. *Supercharged.* Reciprocating engines may be modified by superchargers which serve two purposes. They enable engines to develop more horsepower per unit of weight by increasing the quantity of combustible mixture that can be induced into each cylinder. They also permit engine operation at higher altitudes by compressing the rarefied air to a useable pressure prior to induction into the cylinders. Except for the smallest reconnaissance types, all Army aircraft that use reciprocating engines have superchargers.

- (2) *Weight and power.* Because weight is such a critical factor, aircraft engines are engineered to give the most possible power per pound of weight. To permit rapid acceleration during takeoff (the most dangerous stage of flight) engines are designed to operate for short periods of time at power outputs that would be self-destructive if continued for long periods. For most aircraft engines, this period of excessive power is limited to 5 minutes during any one application. The power ratings of engines used in Army aircraft are usually referred to as one of the following:

- (a) *Takeoff horsepower.* This is the maximum horsepower an engine can develop for a period of 5 minutes or less without immediate damage. Some engines, when operated at the lower altitudes, can exceed this horsepower output. This power, misused, can destroy an expensive engine; it is one of the many reasons for extensive training of aircraft operating personnel.
- (b) *METO horsepower.* This is the maximum horsepower that an engine can develop continuously. (The term METO is derived from the words "maximum, except takeoff.")
- (c) *Cruise horsepower.* This is the horsepower which gives the best speed with minimum engine wear and delivers the best flight characteristics with respect to flight attitude, control response, and minimum vibration.

- (3) *Propellers.* The propellers used on Army fixed-wing aircraft fall into three categories:

- (a) *Fixed pitch.* This is a one-piece, metal propeller used on 0-1 aircraft. The pitch or angle of bite of the propeller blades is fixed and cannot be changed.
- (b) *Constant speed.* This propeller consists of two or three blades and a hub. The hub is designed to permit the blades to change their pitch angle as necessary to maintain a constant engine speed. The desired engine speed is set by the aviator; it is maintained by a governor which transmits its commands to the propeller hub by means of hydraulic pressure, using the engine lubricating oil as a medium.
- (c) *Full feathering.* This is a constant-speed propeller which can be set for a maximum degree of pitch. This enables the aviator to reduce propeller drag to a minimum when one engine of a multiengine aircraft is inoperative. (The Army uses full-feathering propellers on multiengine aircraft only.)

- (4) *Rotors.* The rotor blades used on Army rotary-wing aircraft vary in design and construction, depending on the manufacturer and the desired speed and gross weight of the aircraft. The pitch angle or bite of the blades on all rotary-wing aircraft can be controlled by the aviator. The control mechanism, which is part of the flight-control system of the aircraft is peculiar to the aircraft and is not a property of the rotor blade itself.

d. *Aircraft Balance and Range.*

- (1) *Center of gravity (CG).* The center of gravity of an aircraft is an important factor in flight characteristics and safety. It must be computed by trained personnel for each aircraft for each flight. (Center gravity locations given in this manual are from design data and should be used as guides only.) The computation includes more than the takeoff configuration of the aircraft; it must also consider the progressive change of the center of gravity as fuel is consumed in flight. An aircraft could be loaded so that it would be completely safe at takeoff, but be enough out of balance at the end of the

mission that the aviator could lose control, especially during letdown or landing. Each aircraft varies in weight and balance from other aircraft, even of the same type, model, and series. The actual basic weight and center of gravity of each must be known before center of gravity changes due to load and fuel can be computed.

- (2) *Linear measurements.* Linear measurements of cargo compartments are usually expressed in inches. For fore and aft measurements, the locations are referred to as stations. The station points are used in computing the fore and aft CG of the aircraft; all stations are computed as having a plus factor. Station zero (reference datum line) on most aircraft is usually at the nose of the aircraft or at an imaginary point in front of the aircraft. To eliminate the possibility of having to use negative station factors in the future, the imaginary location in front of the aircraft is set by the designers as the most forward position to which future modifications can reasonably be expected to extend.

- (3) *Operating distances and fuel load.*

- (a) *Range.* For the purposes of this manual, unless otherwise noted, range is the one-way distance that an aircraft can fly with the stipulated load, without refueling, based on the following assumptions:

1. Takeoff altitude is sea level.
2. Flight altitude for the mission is 5,000 feet.
3. Wind condition at altitude is zero.
4. Fuel reserve on arrival at destination is 30 minutes for VFR flights. For IFR flights, the fuel reserve upon arrival at intended destination permits flying to an alternate airport, plus 45 minutes' flight at cruising power.
5. Fuel allowances is made for taxi, run-up, takeoff, and climb-out to altitude.

- (b) *Radius of action.* Radius of action, or radius, is the maximum distance that an aircraft can fly with payload to a destination and return empty without refueling, unless otherwise specified

(return fully or partially loaded). Reserve conditions for this type of mission are the same as in (a)4 above. A further fuel allowance must be made for one additional run-up, taxi, take-off, and climb-out.

e. Considerations Peculiar to Helicopters.

- (1) "In-ground effect" takeoff. The flight characteristics of the helicopter are affected by the high-pressure region or "ground cushion" between the helicopter and the ground. This cushion, created by the downward displacement of air through the rotor blades, is effective to a height of approximately one-half the rotor diameter and increases the lift capability of the helicopter. The use of this takeoff technique increases safety and decreases wear on the engine, power train, and associated equipment. It requires horizontal flight near the ground until sufficient speed is attained for safe flight.
- (2) "Out-of-ground effect" takeoff. When this vertical takeoff method is used, the

ground cushion is lost almost immediately after lift-off (height of one-half the rotor diameter). Usually this takeoff method is employed when a sling load is to be lifted or when the takeoff area is too restricted to permit a ground run or low-level flight. When possible, other methods should be used since payload is reduced and certain risks are involved in this technique. The lift capability, or power, which the engine can develop at maximum continuous power in a vertical takeoff is never equal to the lift capability of the helicopter under forward flight using normal cruise power. If the engine fails above the ground cushion before altitude or forward speed permits autorotational landing, the helicopter may be destroyed or seriously damaged.

- (3) "Ground run" takeoff. This type of takeoff employs the same technique used for fixed-wing aircraft and involves a run over the ground until sufficient speed is attained for safe flight. It is employed when the altitude, temperature, or aircraft

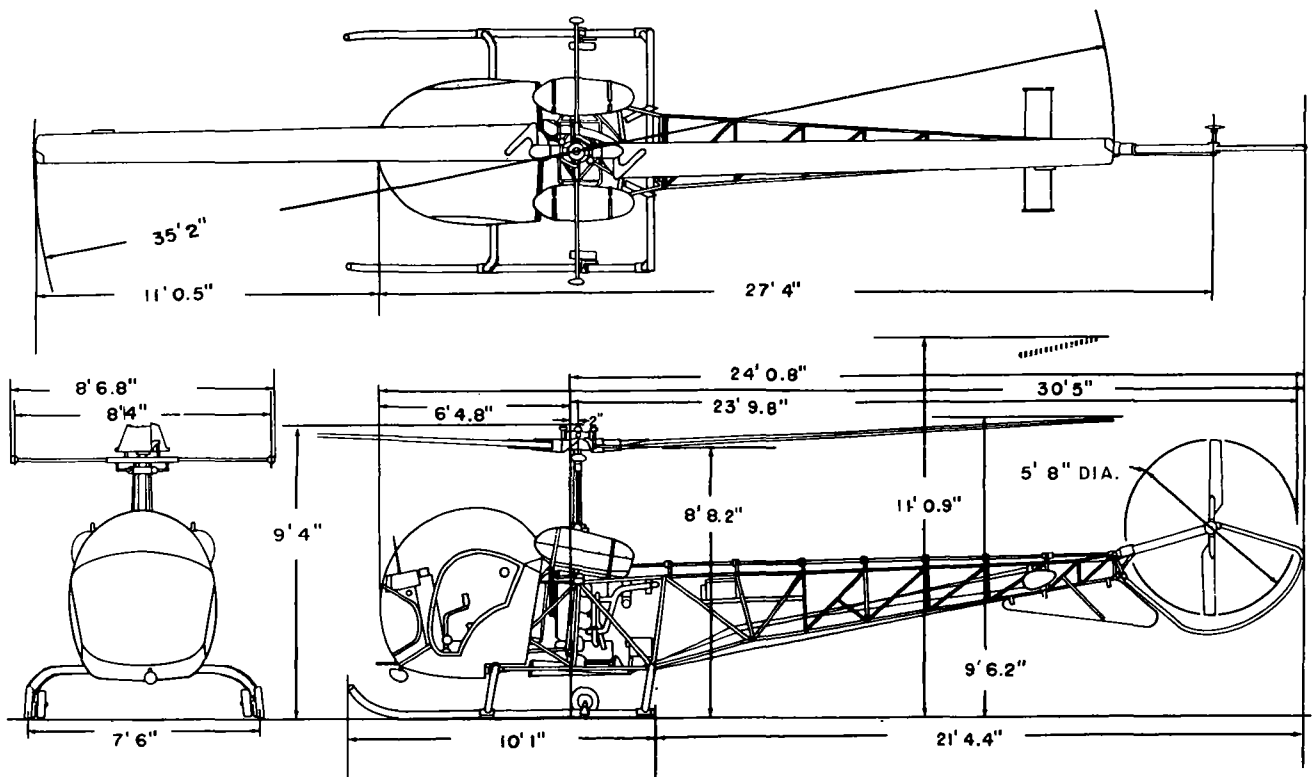


Figure 2.1. OH-13H (Sioux).

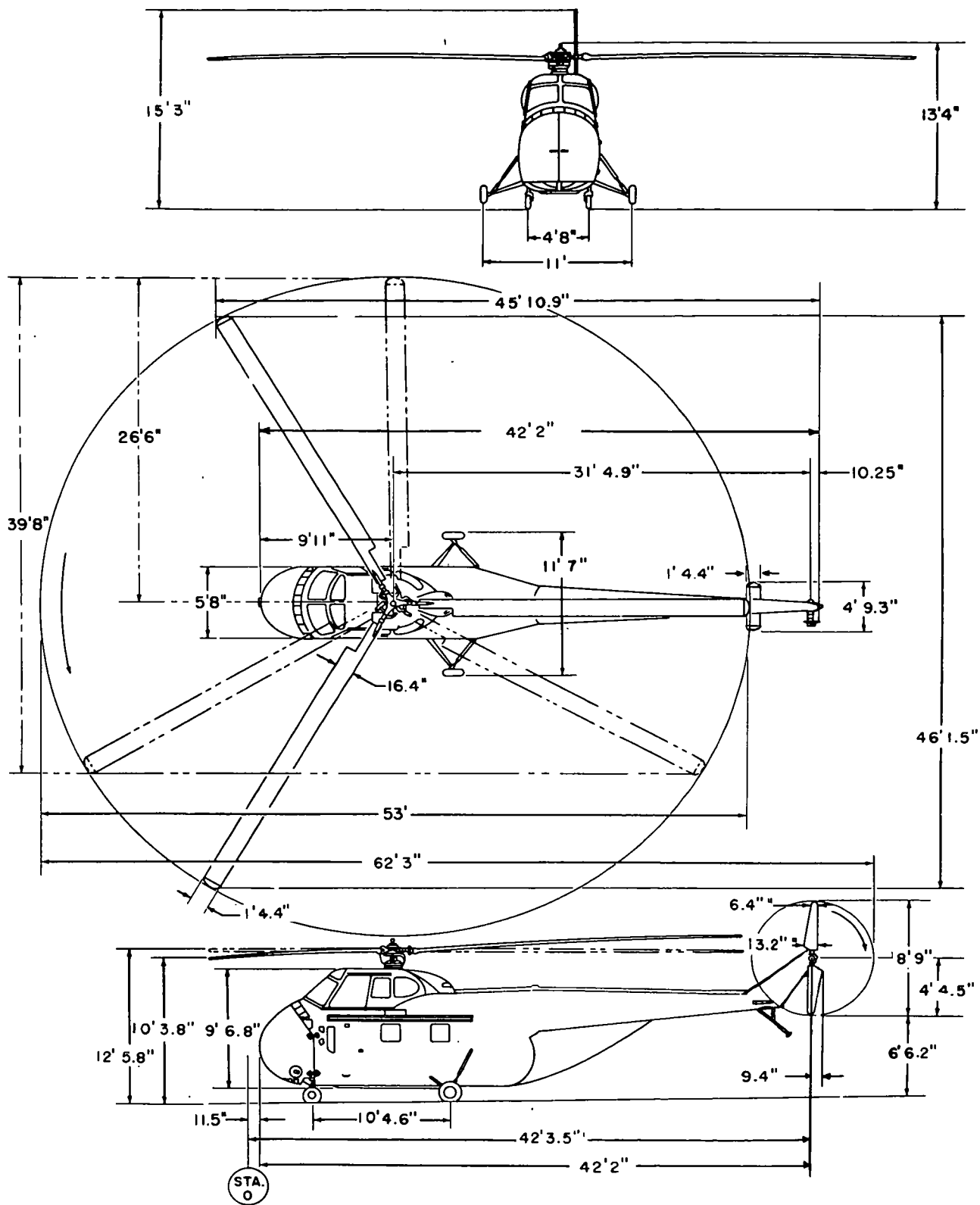


Figure 2.2. UH-19D (Chickasaw).

weight (or a combination of these factors) is such that the aircraft cannot hover close to the ground.

f. *Transportability.* For disassembly, crating,

and crated and uncrated shipment of Army aircraft, see appropriate technical manuals for the aircraft, including manuals of the TM 55-450-series, and FM 101-10.

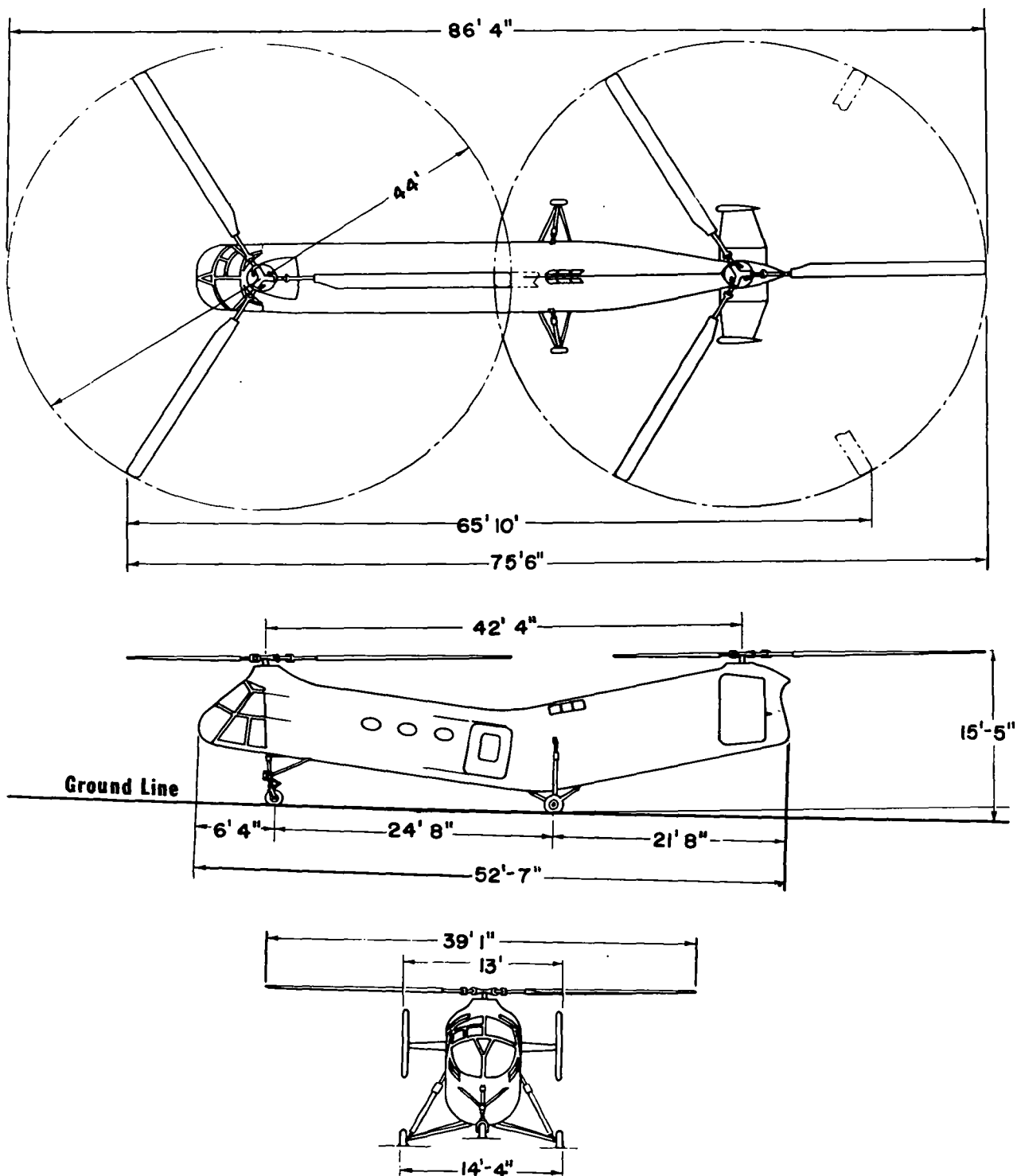


Figure 2.3. CH-21C (Shawnee).

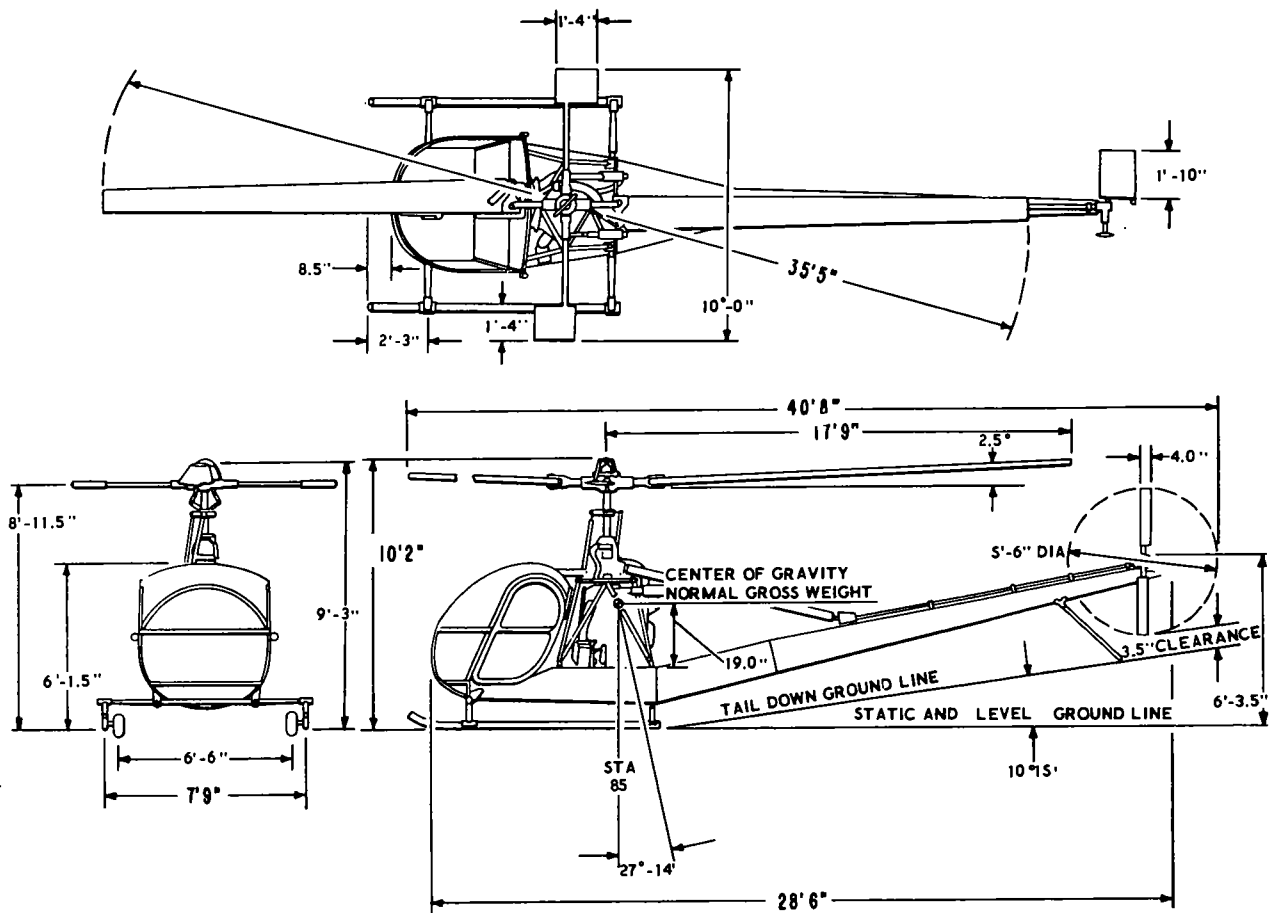


Figure 2.4. OH-23D (Raven).

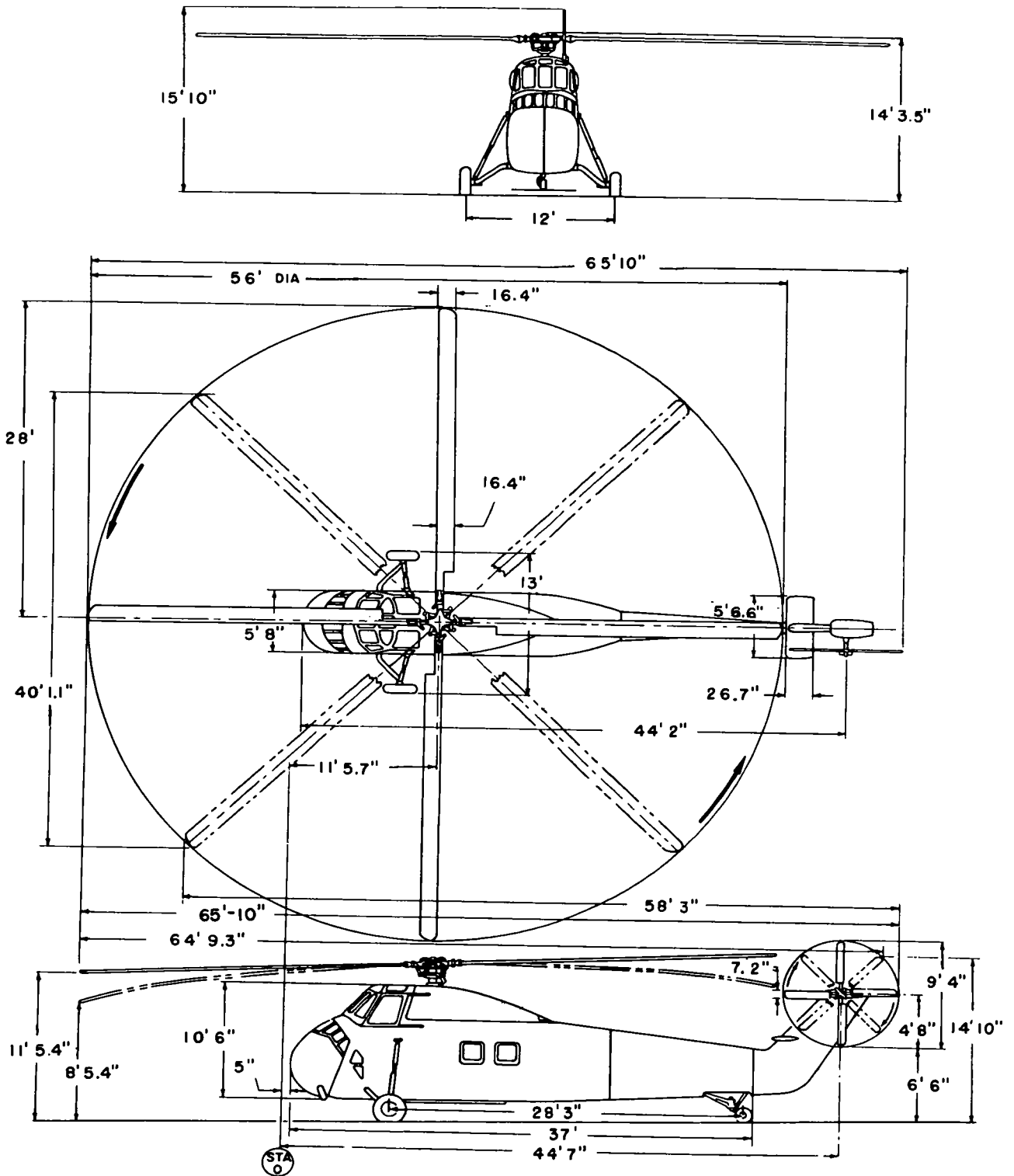


Figure 2.5. CH-34C (Choctaw).

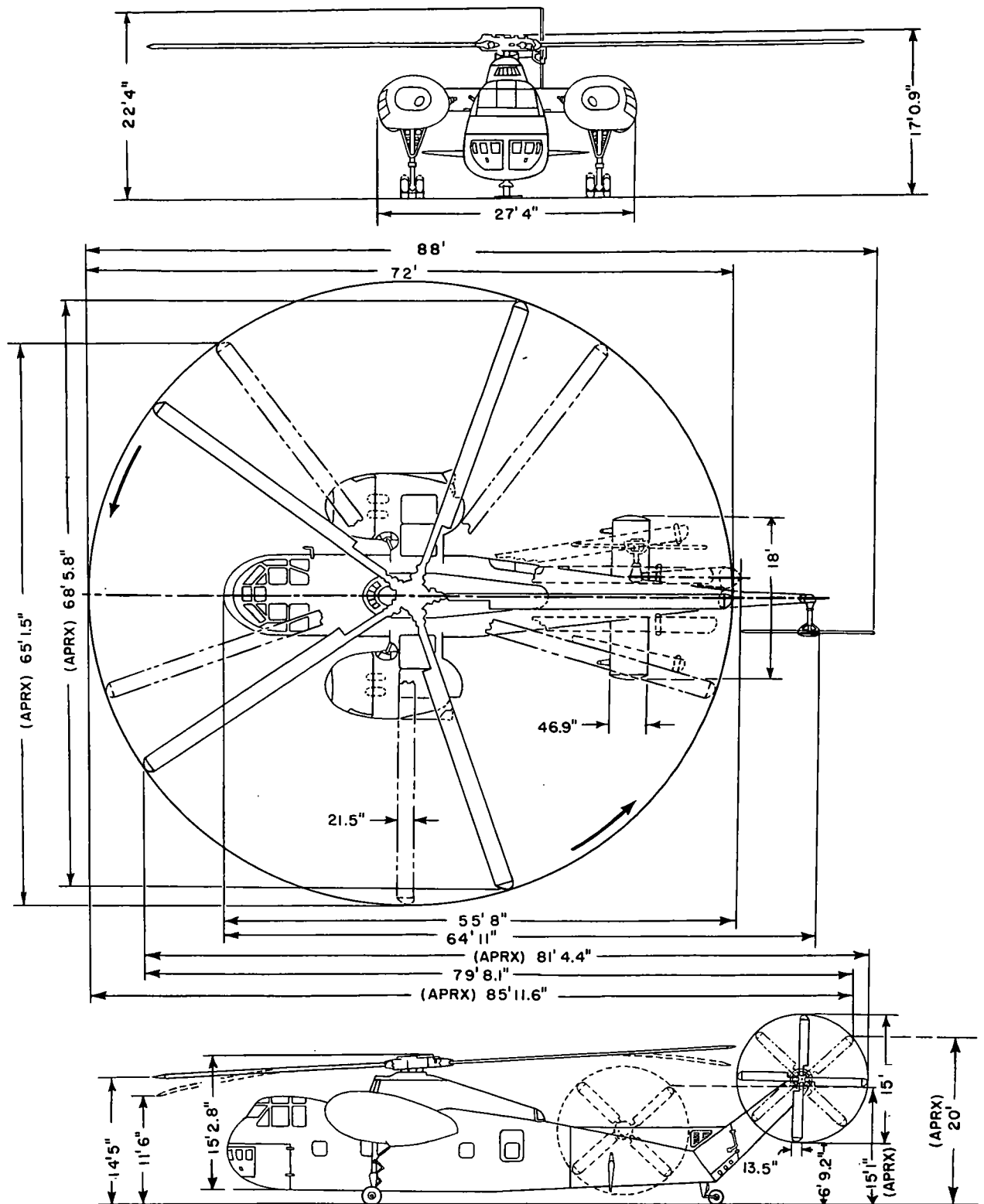


Figure 2.6. CH-53B (Mojave).

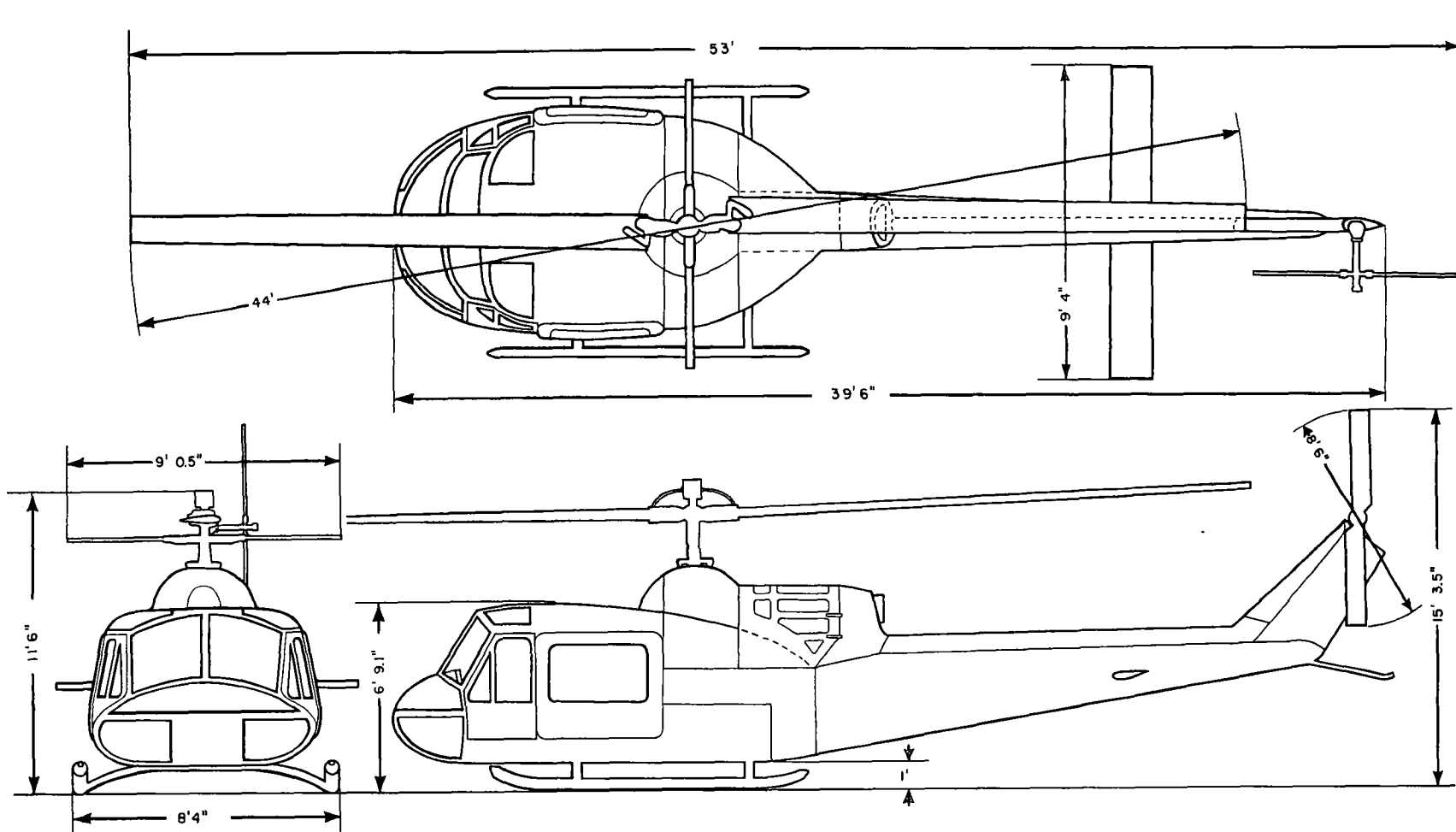


Figure 2.7. UH-1B (Iroquois).

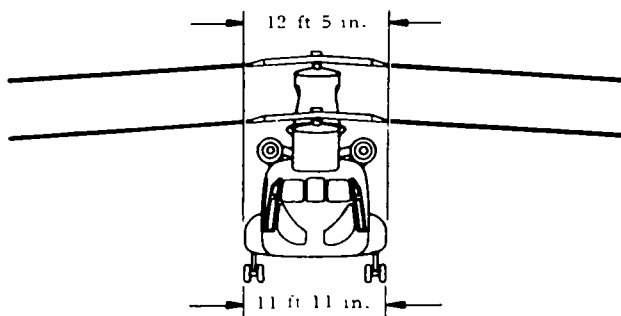
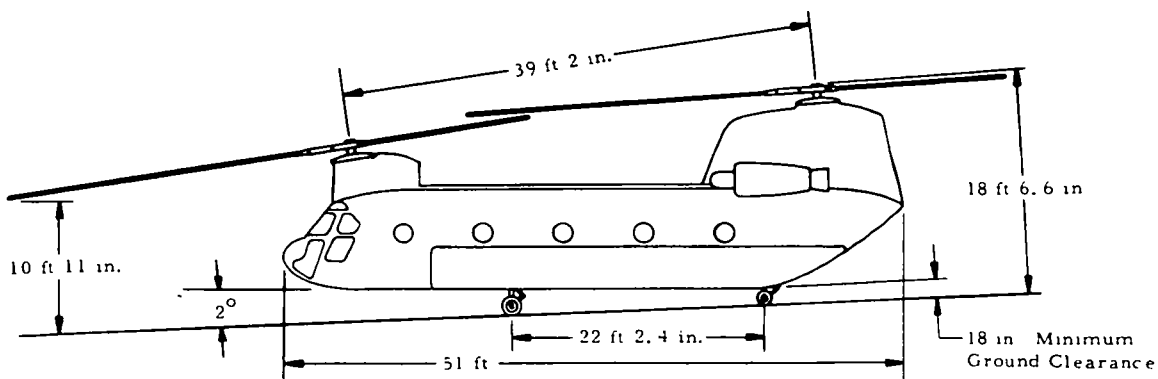
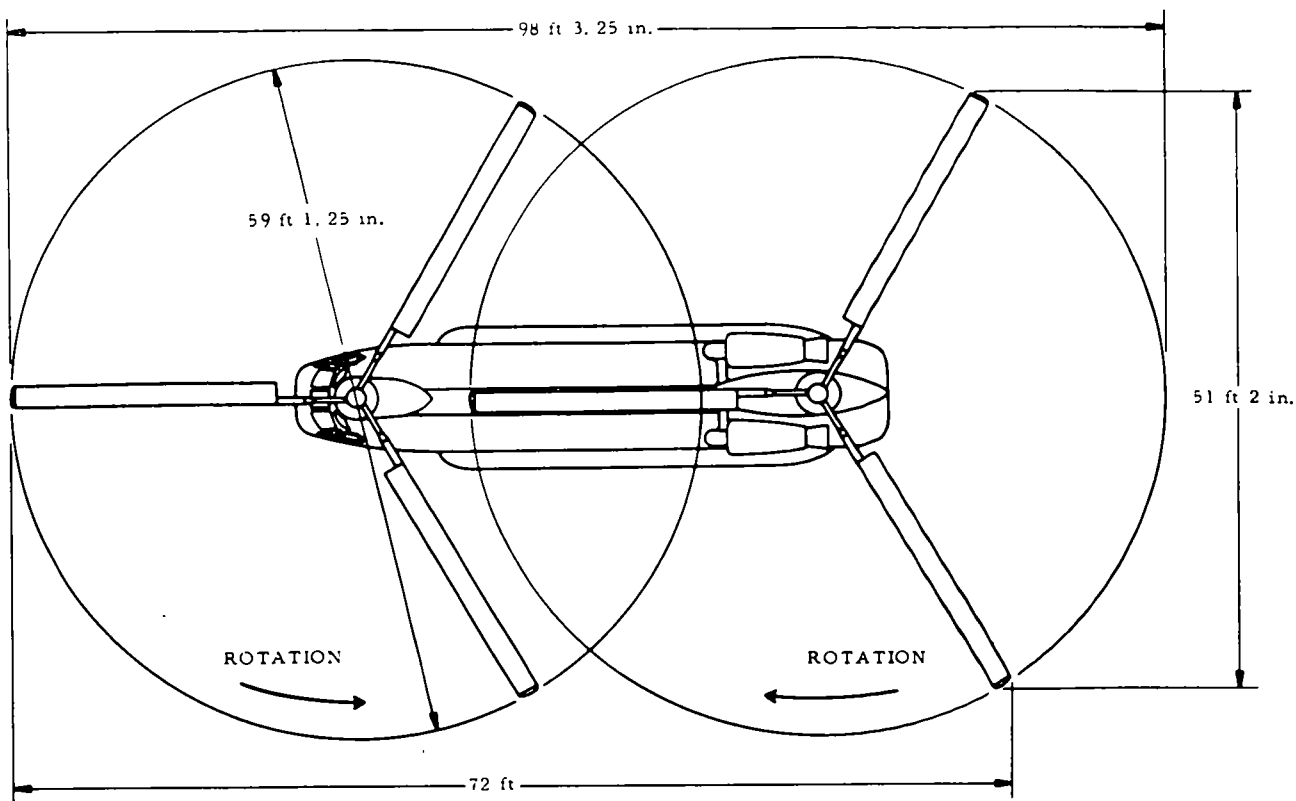


Figure 2.8. CH-47A (Chinook).

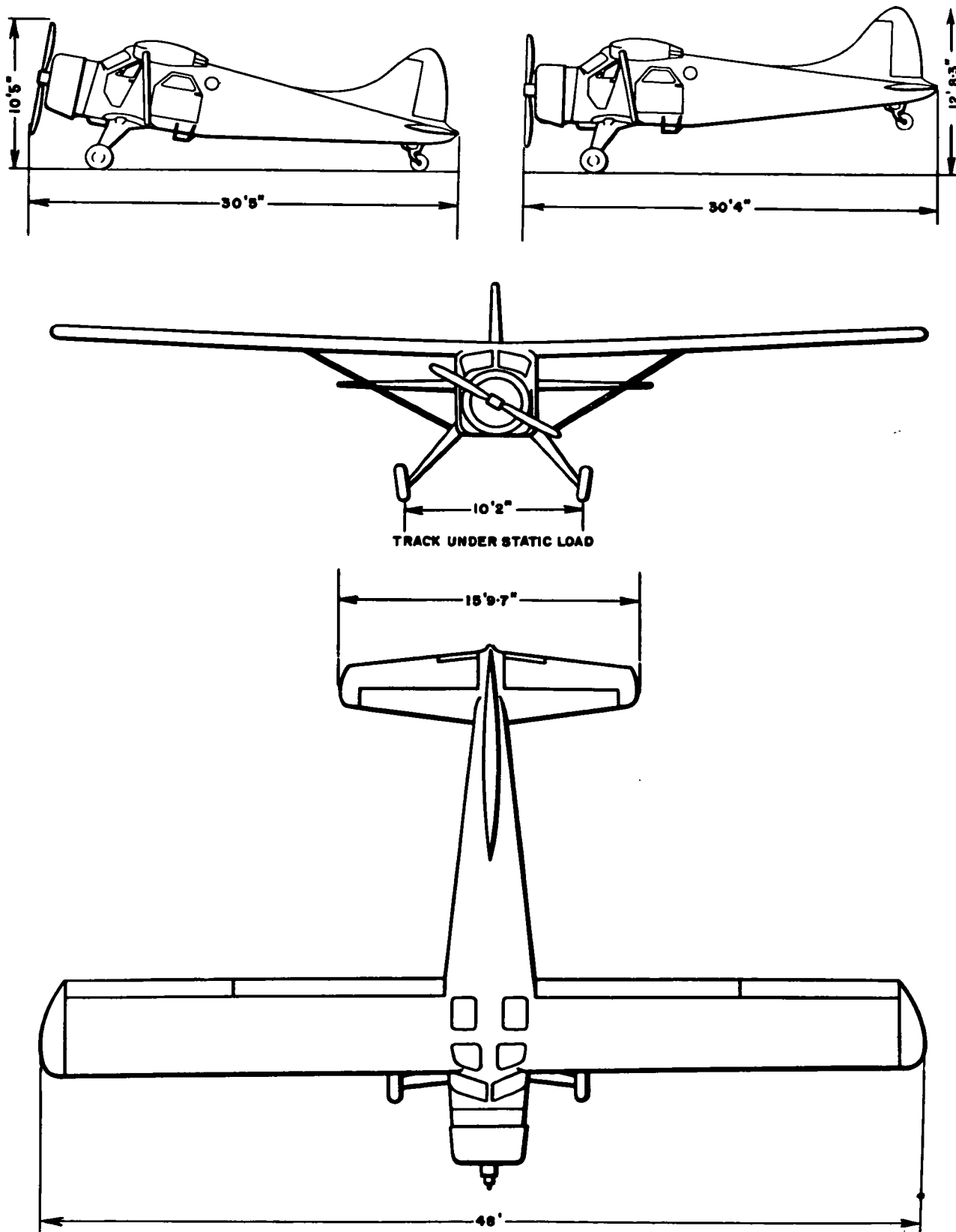


Figure 2.9. U-6A (Beaver).

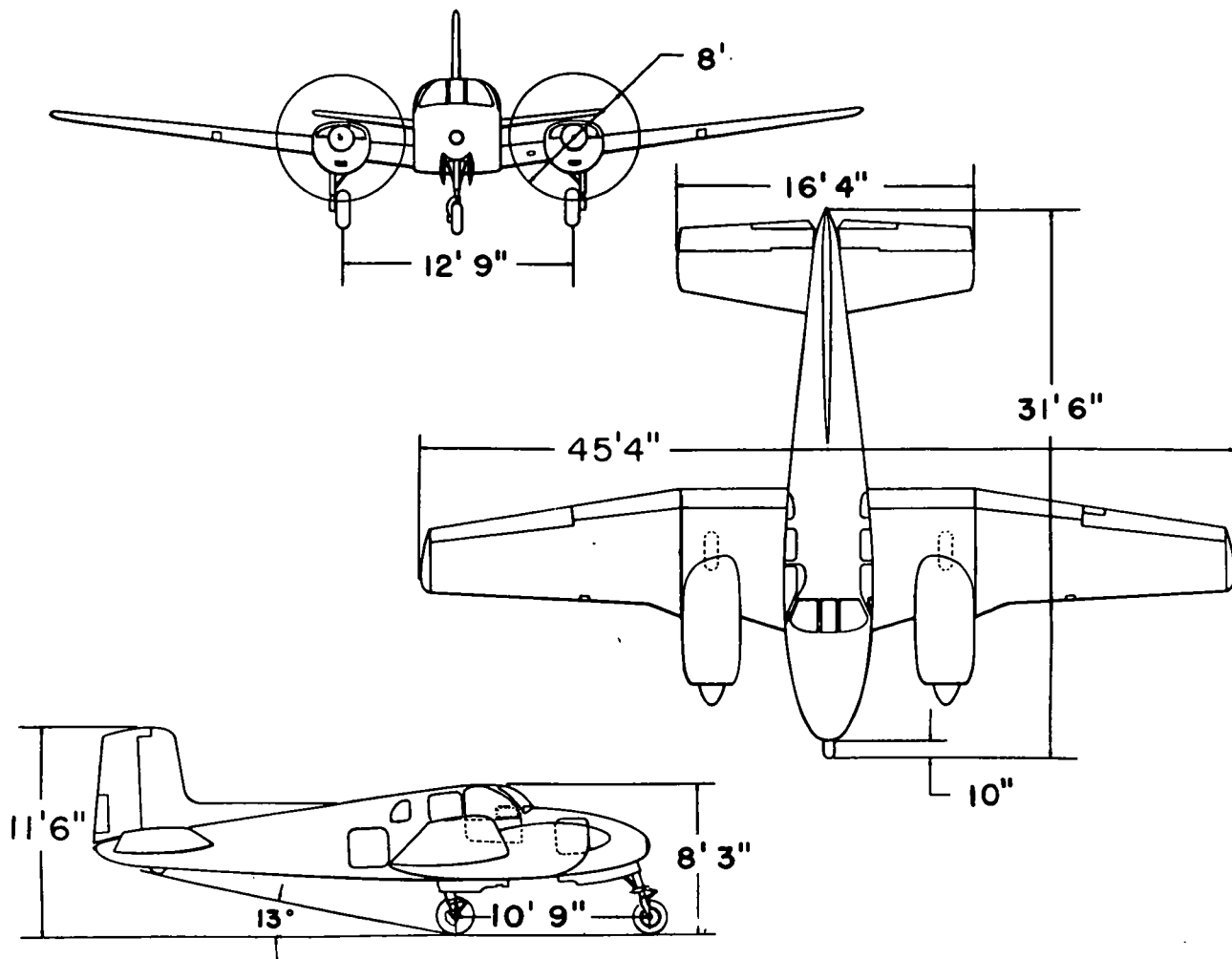


Figure 2.10. U-8D (Seminole).

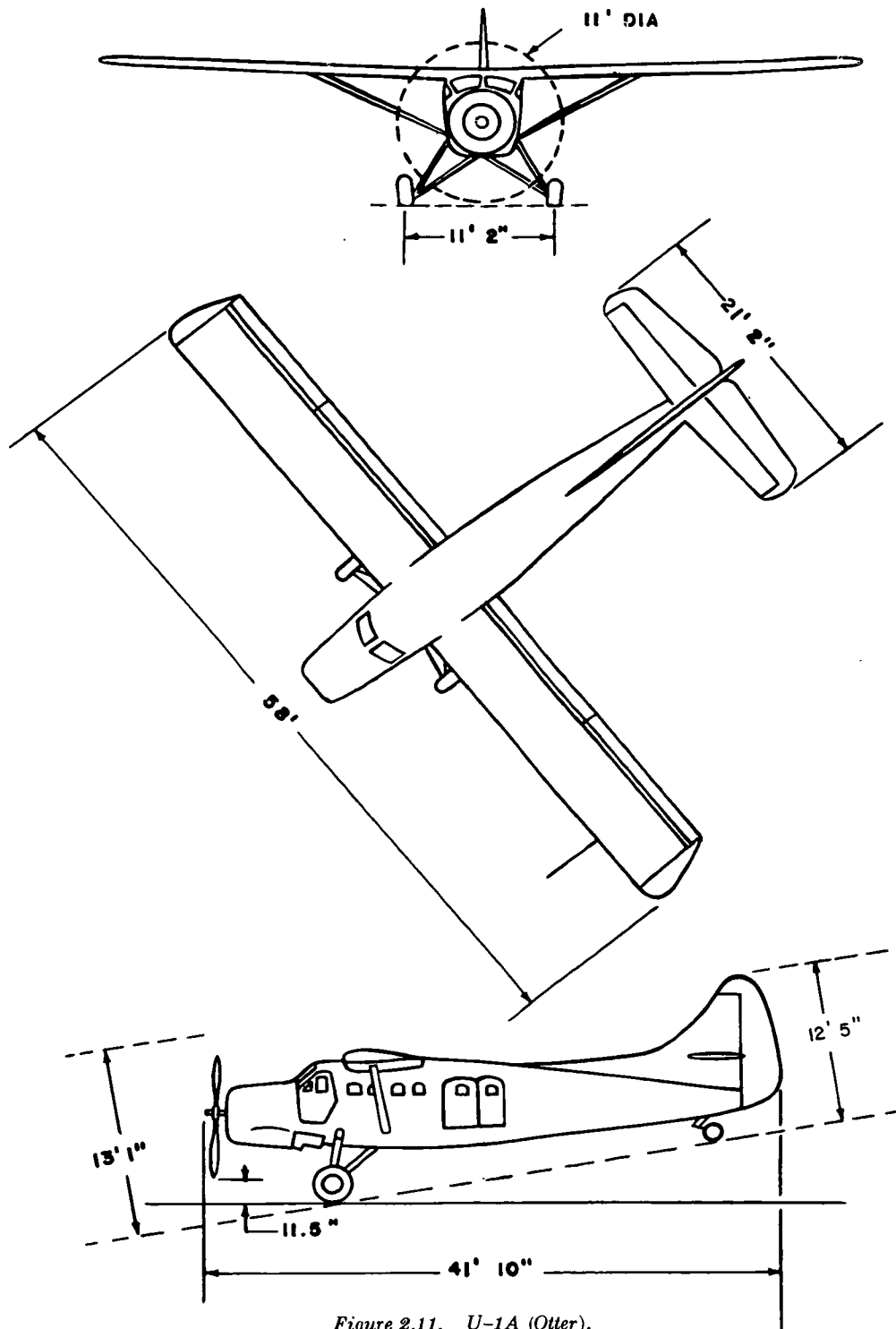


Figure 2.11. U-1A (Otter).

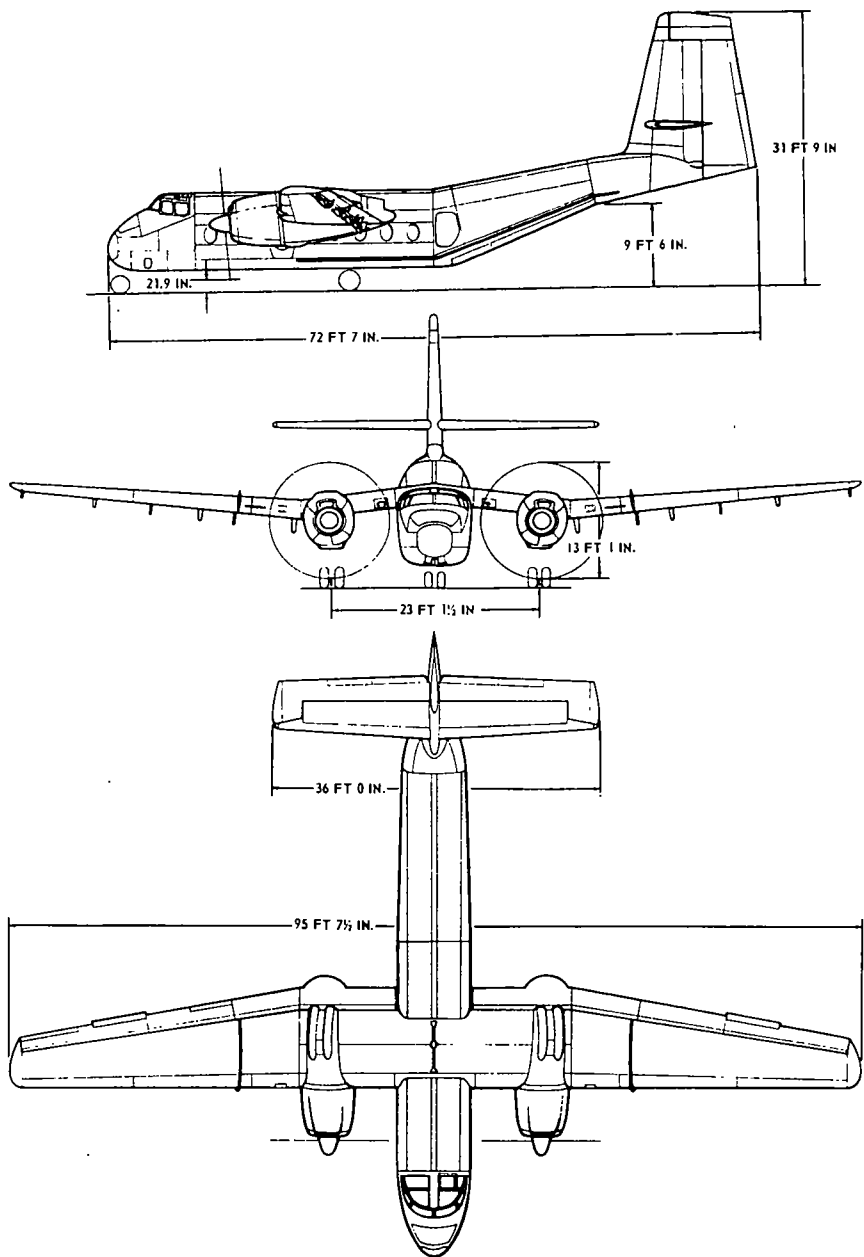


Figure 2.12. CV-2A (Caribou).

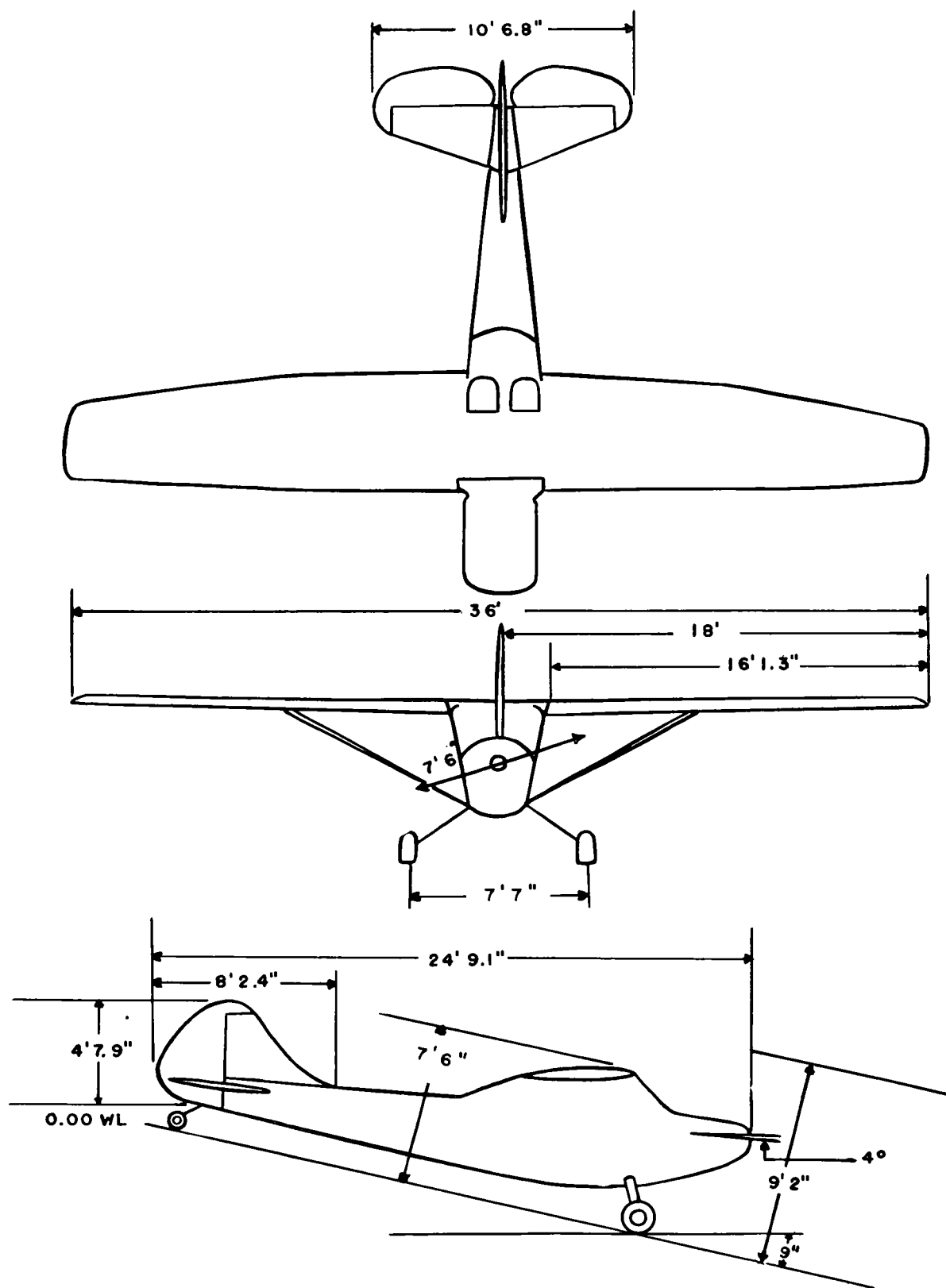


Figure 2.13. O-1E (Bird Dog).

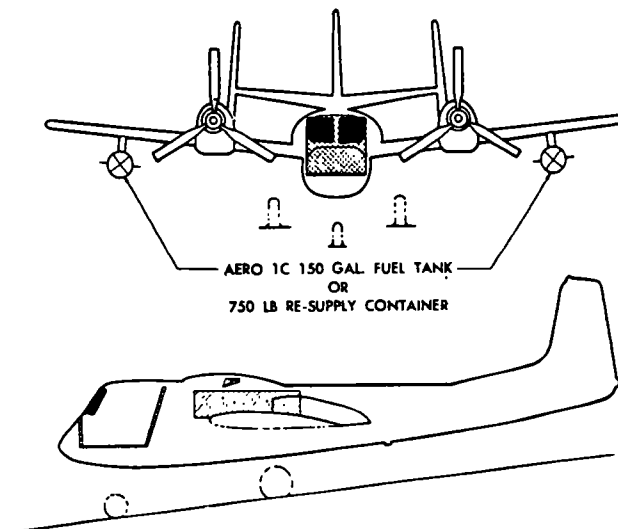
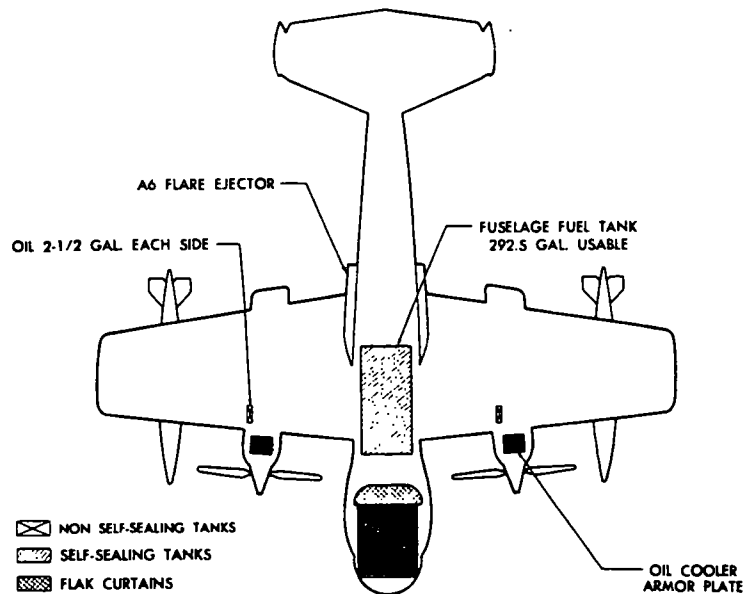
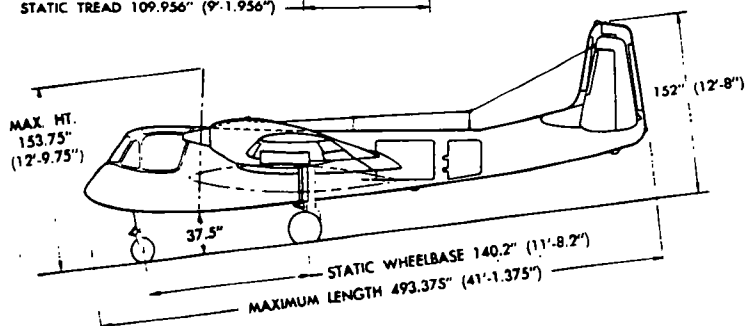
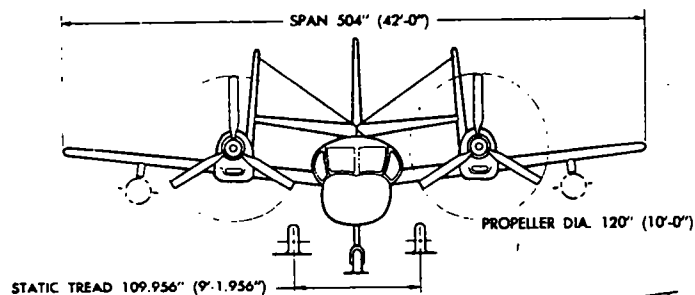
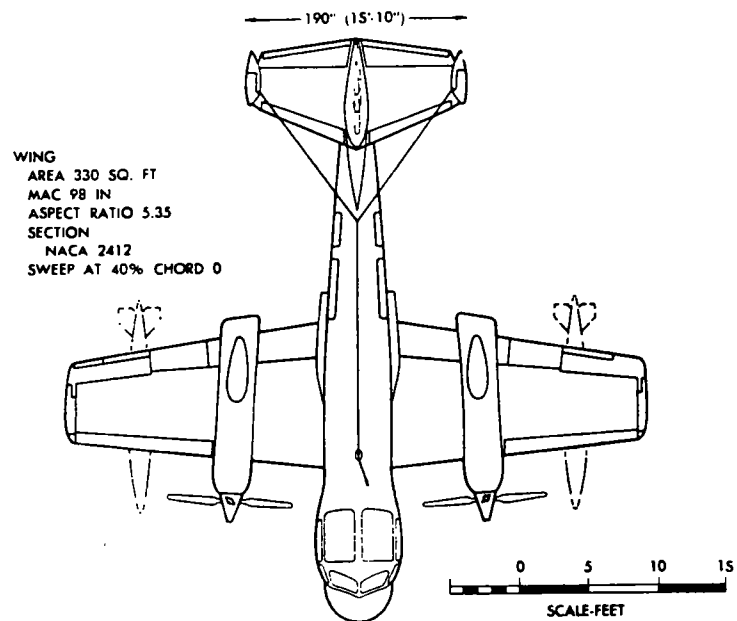


Figure 2.14. OV-1A (Mohawk).

2.3 Army Aircraft Characteristics

(figs. 2.1-2.14)

Use operational data shown below as a planning guide only. Variations in weather, altitude, humidity, and other conditions will cause the values to vary.

a. Crew, Passengers, and Critical Dimensions.

	O-1E (Bird Dog)	OV-1A (Mohawk)	U-6A (Beaver)	U-1A (Otter)	U-8D (Seminole)	CV-2 (Caribou)	OH-13G (Sioux)	OH-13H (Sioux)	OH-23C (Raven)	OH-23D (Raven)	UH-19D (Chickasaw)	UH-1A (Iroquois)	UH-1B (Iroquois)	CH-21C (Shawnee)	CH-34C (Choctaw)	CH-37B (Mojave)	CH-47A (Chinook)
Recommended crew (200 lbs per man).....	1	2 ^a	1	2	1	2	1	1	1	1	2	1	2	2 ^b	2 ^b	3 ^b	2 ^b
Passenger capacity:																	
Troop seats (240 lbs per man) ^c	1	0	4	8	4	32	1	1	2	2	10	4	6	20	12	23	33
Patients ^d :																	
Litters.....		NA	2	6	NA	14	2 ^e	2 ^e	2 ^e	2 ^e	6	2	2	12	8	24	24
Ambulatory.....	1		2	3		8						3					
Dimensions (ft and in.):																	
Length—fuselage.....	25'10"	41'0"	30'5"	41'10"	31'6"	72'7"	31'5"	31'5"	28'2"	28'6"	42'2"	39'6"	39'6"	52'7"	46'9"	64'11"	49'10"
Length—blades unfolded.....	NA	NA	NA	NA	NA	NA	41'5"	41'5"	40'6"	40'8"	62'3"	52'10"	53'0"	86'4"	65'10"	88'0"	98'2"
Length—blades folded.....	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	42'2"	NA	NA	52'7"	37'0"	55'8"	49'10"
Width—blades folded.....	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	11'7"	9'4"	NA	14'0"	13'0"	27'4"	12'1"
Width—tread.....	7'7"	9'2"	10'2"	11'2"	12'9"	23'11½"	7'6"	7'6"	7'6"	7'9"	11'0"	8'4"	8'4"	14'4"	12'0"	19'9"	10'4"
Height—extreme.....	7'6"	12'8"	9'0"	12'5"	11'6"	31'9"	8'8"	9'4"	9'10"	10'2"	15'3"	15'2"	11'6"	15'5"	15'10"	22'4"	18'6"
Diameter—main rotor.....	NA	NA	NA	NA	NA	NA	35'2"	35'2"	35'0"	35'5"	53'0"	43'9"	44'0"	44' ea	56'0"	72'0"	59'0"
Diameter—tail rotor.....	NA	NA	NA	NA	NA	NA	5'8"	5'8"	5'6"	5'6"	8'9"	8'5"	8'6"	NA	9'4"	15'0"	NA
Wing span.....	36'0"	42'0"	48'0"	58'0"	45'4"	96'5"	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tire size (in.).....	6.00×6	8 50×10	8.50×10	11.00×12	8.50×10	11.00×12	NA	NA	NA	NA	7.50×10	NA	NA	24.00×7.7	11.00×12	8.50×10	22×5.5
Cargo door:		6.50×8									6.00×6				6.00×6	6.00×6	16×4.4
Dimensions (in.):																	
Width.....	45"	NA	39" (max)	46" (L.)	30"	73½"	NA	NA	NA	NA	48"	48"	48"	45" (cargo)	52"	87"	90"
Height.....	33"		40" (min)	45" (R.)	30"	74"					48"	48"	48"	59" (rsq)	48"	67" (nose)	78"
			40"	45"										59"		72" (bottom)	
																48" (right)	
Location on fuselage.....	Right	NA	Right & left	Right & left	Right	Rear	NA	NA	NA	NA	Right	Right & left	Right & left	Right (rescue) left (cargo)	Right	Nose bottom right	Rear
Cargo compartment:																	
Height of floor above ground (in.).....	22"	NA	46"	46"	NA	45½"	NA	NA	NA	NA	30"	27"	26"	38"	34"	36"	30"
Length—useable (in.).....	NA	NA	76"	152"	NA	(l)	NA	NA	NA	NA	120"	48"	48"	240"	164"	364"	360"
Width—floor (in.).....	NA	NA	48"	52"	NA	73½"	NA	NA	NA	NA	60"	80"	80"	50"	59"	81"	90"
Height—clear of obstructions.....																	

Dimensions (in.).....	NA	NA	51"	59"	NA	74"	NA	NA	NA	NA	72"	48"	48"	62"	70"	67"	78"
Cargo space (max) (cu ft)....	NA	NA	125	286	NA	1,090	NA	NA	NA	NA	300	109	107	422	363	1,142	1,462

^a Figures are from design data and are subject to change.

^b Unit SOP may include crew chief in addition to crew shown.

^c Seats shown are those in the passenger compartment of the aircraft.

^d Litter spaces shown may be used for ambulatory patients. When both litter and ambulatory spaces are shown, any combination of the total number may be used.

^e Cargo may be carried on litter racks in lieu of patients.

^f 28'9" to forward edge of loading ramp; 32'6" to aft edge of loading ramp.

b. Range, Loading, Lashing, and Balance Factors.

	O-1E	OV-1A	U-6A	U-1A	U-8D	CV-2	OH-13G	OH-13H	OH-23C	OH-23D	UH-19D	UH-1A	UH-1B	CH-21C	CH-34C	CH-37B	CH-47A
Max range (ferry) ^a :																	
Nautical miles.....	350	1,500	590	900	1,260	1,017	150	170	88	158	230	188	141	295	240	200	1,037
Kilometers.....	648	2,780	1,095	1,670	2,330	1,880	278	315	163	293	426	348	261	547	445	370	1,920
Max range with payload (full fuel) ^a :																	
Nautical miles.....	350	400	575	720	980	850	145	170	77	135	185	82	126	255	195	180	200
Kilometers.....	648	742	1,065	1,335	1,815	1,575	269	315	143	250	343	152	234	473	361	334	370
Average cargo payload (lb) vs range ^b																	
Nautical miles Kilometers																	
250 463	(c)	(c)	1,135	1,960	(c)	5,100											
300 556			1,120	1,885		4,900											
350 649			1,105	1,810		4,675											
400 741			1,090	1,735		4,475											
450 833			1,075	1,660		4,275											
500 926			1,060	1,585		4,050											
550 1,020			1,045	1,510		3,875											
600 1,110				1,435		3,650											
650 1,205				1,360		3,450											
700 1,297				1,285		3,250											
750 1,390						3,025											
800 1,482						2,800											
850 1,575						2,625											
900 1,666																	
950 1,760																	
External cargo:																	
Maximum recommended external load (lb) ^d	145 ^e	1,950	500	NA	NA	NA	NA	NA	NA	NA	1,000	2,500	2,200	3,000	4,000	10,000	16,000
per wing			per wing														
Rescue hoist capacity (lb).....	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	400	NA	NA	400	600	600	600
Floor load capacity (psi):																	
Distributed ^f	NA	NA	0.7	0.35-1.05	NA	13	NA	NA	NA	NA	0.327	-----	1.04	0.9	1.4	2.08	1.4
Concentrated.....	NA	NA	1.4	1.4	NA	40	NA	NA	NA	NA	-----	-----	2.08	2.36	-----	4.8-11.1	10-25
Capacity (lb) per running foot of cargo compartment ^f	NA	NA	400	655	NA	1,200	NA	NA	NA	NA	235	1,000	1,000	500	990	2,020	1,510
Special cargo handling equipment capacities ^g :																	
External hook and sling.....	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20	25	25	50	40-50	100	160
Tiedown fittings in floor.....	NA	NA	9	22	NA	54	NA	NA	NA	NA	-----	12	12	25	34	18 94	87 8

See footnotes on page 24.

	O-1E	OV-1A	U-6A	U-1A	U-8D	CV-2	OH-13G	OH-13H	OH-23C	OH-23D	UH-19D	UH-1A	UH-1B	CH-21C	CH-34C	CH-37B	CH-47A
Tiedown fittings on each side...	NA	NA	-----	20	NA	50	NA	NA	NA	NA	-----	-----	12.5	20	12	50 22	50 100
	NA	NA	-----	23	NA	2 18	NA	NA	NA	NA	-----	NA	NA	1 10	NA	NA	
	NA	NA	-----	20	NA	100 20	NA	NA	NA	NA	-----	NA	NA	50 20	NA	NA	
Hoist winch.....	NA	NA	-----	-----	NA	20	NA	NA	NA	NA	6	NA	-----	4	6	20	30
Restraint safety factors ^b :																	
Forward.....	NA	NA	-----	9	NA	8	NA	NA	NA	NA	4	4	4	4	4	4	4
Rearward.....	NA	NA	-----	2	NA	2	NA	NA	NA	NA	2	2	2	2	2	2	2
Vertical.....	NA	NA	-----	2	NA	2	NA	NA	NA	NA	2	2	2	2	2	2	2
Sideward.....	NA	NA	-----	1.5	NA	1.5	NA	NA	NA	NA	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Center of gravity (in.) ^c	137- 140	143- 153	93.4- 107.7	134.2- 147.8	114- 124.6	347.4- 357.1	(1) 5-2	(1) 5-2	79.5 84.8	79.5 84.8	125- 136	128.0- 137.5	128.0- 137.5	36- 6.5	130.7- 146.7	228- 245.1	35.3- 11.8

^a Includes 30-minute fuel reserve.

^b Use figure 2.15 when planning for shorter distances.

^c Primarily passenger-type aircraft.

^d Limited by payload.

^e With total fuel and no passenger. Maximum allowable overload of 250 pounds per wing should be used only with minimum fuel required for the mission.

^f Applies only up to the weight-carrying capacity of the aircraft.

^g All capacities are shown in hundreds of pounds. For tiedown fittings, top line shows number of fittings; bottom line shows capacities.

^b Use the following formula to determine the number of lashings required to secure a piece of cargo with a prescribed angle of tie against one thrust direction. Number of lashings required =

$$\frac{\text{Weight of cargo (lb)} \times \text{restraint safety factor} \times 100}{\text{Tensile strength of lashing (lb)} \times \text{percent effectiveness of system}}$$

¹ Forward and aft center of gravity limitations from reference-datum line (RDL), unless otherwise noted.

² Forward and aft of center line of rotor mast.

³ Forward and aft of midpoint between rotor masts.

c. Miscellaneous Operational and Other Data.

	O-1E	OV-1A	U-6A	U-1A	U-8D	CV-2	OH-13G	OH-13H	OH-23C	OH-23D	UH-19D	UH-1A	UH-1B	CH-21C	CH-34C	CH-37B	CH-47A
Max recommended gross weight (lb).....	2,400 ^a	14,018	5,100	7,600	7,000	28,500	2,350	2,350	2,500	2,700	7,300	7,200	6,400	13,500	13,300	31,000	33,000 ^b 23,300 ^c 25,600 ^d
Operating weight (lb) ^e	1,865	10,694	3,547	5,201	5,260	17,400	1,752	1,887	1,944	1,998	6,100	4,220	4,220	9,700	8,428	22,335	16,000
Payload and fuel (lb) ^f	535	3,324	1,553	2,399	1,740	8,600	698	463	556	702	1,200	2,980	2,180	3,800	4,872	8,646	7,242 ^e 9,717 ^d
Cruise speed with payload (TAS):																	
Knots.....	87	200	105	100	160	156	60	70	60	60	65	69	80	70	76	80	130
Kilometers per hour.....	161	371	195	185	296	289	111	129	111	111	120	-----	148	129	139	148	241
Max cruise speed with payload (TAS):																	
Knots.....	96	275	110	106	170	180	78	80	73	80	80	69	90	85	90	80	148 ^d 160 ^e
Kilometers per hour.....	178	510	204	194	315	334	144	148	135	148	148	-----	167	157	167	148	274
Max useable fuel capacity (lb)....	246	1,683	828	1,296	1,380	4,332	249	246	159	276	918	812	860	1,800	1,572	4,200	3,126 ^e 3,229 ^d
Fuel consumption (lb) per hour at cruise speed ^g	60	750	144	198	216	1,680	84	84	92	100	270	460	377	615	510	1,320	1,600
Take-off ground roll at sea level ^h :																	
Feet.....	284- 716	660- 1,005	800- 1,000	1,400	1,275- 1,466	340- 726	0	0	0	0	0	0	0	0	0	0	0
Meters.....	87- 218	201- 307	244- 305	427	389- 444	104- 221	0	0	0	0	0	0	0	0	0	0	0
Take-off distance to clear 50-foot obstacle at sea level ^h :																	

Feet.....	110- 1,205	1,010- 1,450	1,175- 1,475	1,700- 2,150	2,100- 2,400	570- 1,200	0- 225	0- 355	0	0	0	0	110	0	0	0- 565	316- 460	0
Meters.....	34- 368	308- 442	358- 450	518- 656	641- 732	174- 366	0- 69	0- 108	0	0	0	0	-----	0	0	0- 172	96- 140	0
Landing distance to clear 50-foot obstacle at sea level ^b :																		
Feet.....	550- 650	858- 1,300	1,120- 1,200	1,260- 1,500	1,970- 2,100	760- 1,110	0- 160	0- 195	0	0	0	0	328	0	0	0- 565	302- 322	0
Meters.....	168- 198	261- 396	342- 366	384- 457	601- 641	232- 338	0- 49	0- 60	0	0	0	0	-----	0	0	0- 172	92- 99	0
Landing ground roll at sea level ^b :																		
Feet.....	260	454	500- 550	1,370	1,215- 1,295	250- 480	0	0	0	0	0	0	0	0	0	0	0	0
Meters.....	79	139	152- 168	418	370- 394	76- 146	0	0	0	0	0	0	0	0	0	0	0	0
Turning radius (ft and in.).....	21'10"	26'7"	35'	38'	30'1"	6'11½"	24'1"	24'1"	23'	23'	33'	31'	31'	48'6"	41'	56'	49'2"	
Type of landing gear (wheels and skids).....	3 sgl wheels	3 dual wheels	2 sgl wheels	2 sgl wheels	3 sgl wheels	3 dual wheels	2 skids	2 skids	2 skids	2 skids	4 sgl wheels	2 skids	2 skids	3 sgl wheels	3 sgl wheels	1 sgl, 2 dual	4 dual wheels	

^a 0-1 has maximum recommended gross weight of 2,400 pounds on long runway and 2,165 pounds for takeoff over barrier.

^b Maximum alternate gross weight mission at sea level, standard atmosphere, and payload and fuel of 16,000 pounds.

^c Primary mission to meet the Army "hot day" requirement of 95° F., 6,000 feet, hovering "out-of-ground" effect with a 2-ton payload. All missions based on a 100-NM radius.

^d Alternate mission to meet the alternate requirement of 100° F., at 3,000 feet, hovering "out-of-ground" effect with a 3-ton payload. All missions based on a 100-NM radius.

^e Includes aircraft, oil, and crew. Does not include useable fuel.

^f May be internal, external, or combination and includes useable fuel and cargo or passengers. When planning for each additional 20 miles of operating radius above 50 NM, reduce UH-19 payload by 10 percent, CH-21 by 9 percent, CH-34 by 5 percent, and CH-37 by 5 percent.

$$\text{Fuel required (lb)} = \frac{\text{Distance (NM)} \times \text{Fuel Consumed Per Hour (lb)}}{\text{Cruise speed (K)}}$$

^g Assuming 59° F., 29.92 inches Hg, and 2,000-foot altitude. Figures shown represent fuel consumption with payload.

^h Varies according to load, temperature, humidity, and headwind. These figures give general planning information for emergency airfields.

2.4 Army Aircraft Payload Versus Range

a. *General.* Payload is the number of passengers and/or the amount of cargo that an aircraft can carry, usually expressed in pounds. As the distance to be flown is increased, the fuel required is increased and the payload is decreased. The payload varies with changes in altitude, temperature, air pressure, humidity, and wind.

b. *Computations for Range Versus Payload.* Payload for various ranges may be closely ap-

proximated for Army aircraft by using figure 2.15, which has been constructed from computations for 50, 100, and 200 nautical miles shown in the table in c below. In computing total payload for the mileages shown, the maximum possible payload is used. Pounds of fuel not required to fly the mission have been replaced with payload. Figure 2.15 is a rapid reference that should be used for general planning only. When planning cargo operations over distances greater than 220 nautical miles, see paragraph 2.3.

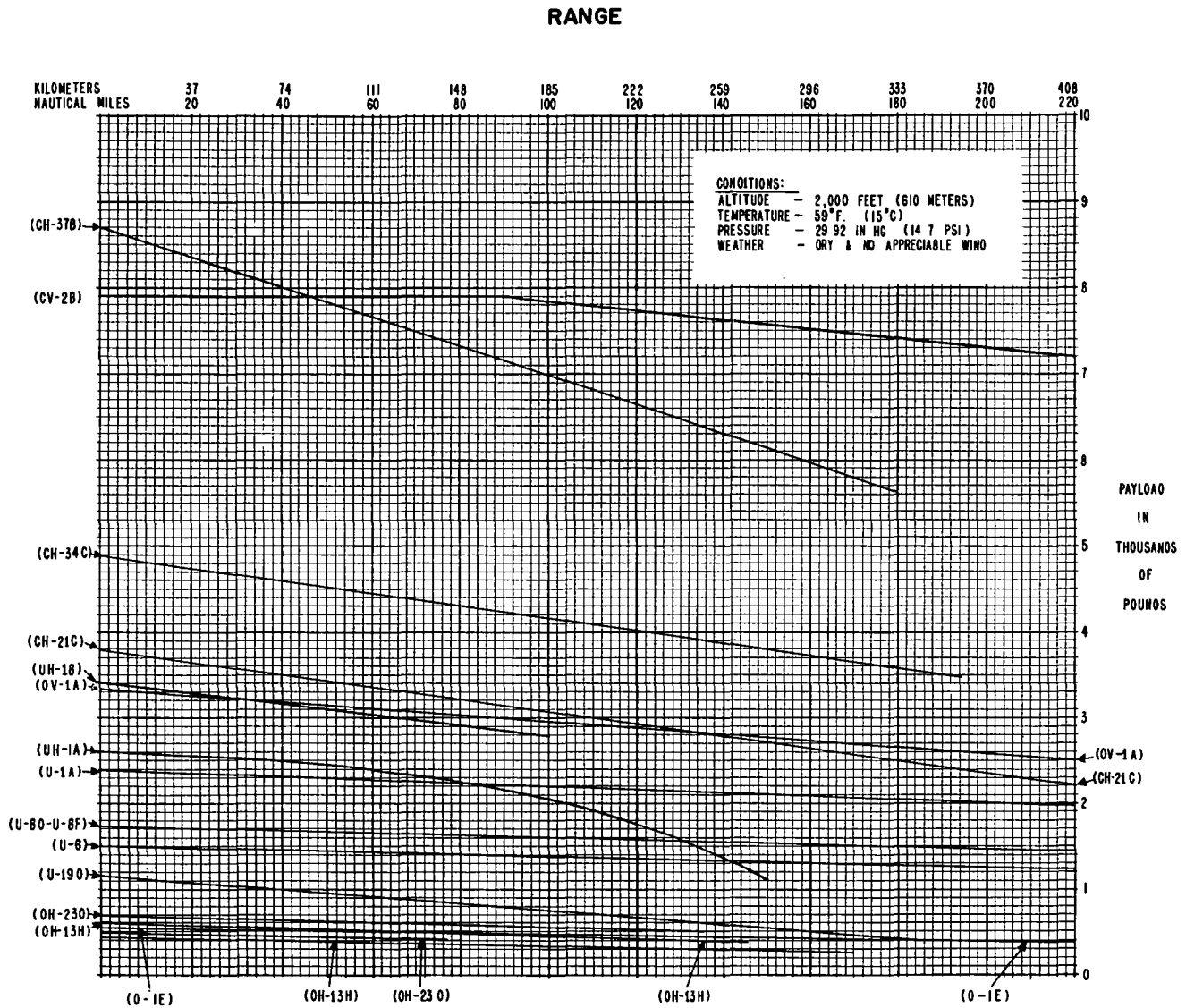


Figure 2.15. Payload versus range of Army Aircraft.

c. Nautical Miles Computation.

	O-1E	OV-1A	U-6A	U-1A	U-8D	CV-2	OH-13G	OH-18H	OH-23C	OH-23D	UH-19D	UH-1B	CH-21C	CH-34C	CH-37B	CH-47A
Maximum gross weight (take-off).....	2,400	14,018	5,100	7,600	7,000	26,000	2,350	2,350	2,500	2,700	7,300	6,400	13,500	13,300	31,000	23,300
Basic opnl weight subtracted.....	1,865	10,694	3,547	5,201	5,260	17,400	1,752	1,887	1,944	1,998	6,100	4,220	9,700	8,428	22,355	16,000
Fuel and payload.....	535	3,324	1,553	2,399	1,740	8,600	598	463	556	702	1,200	2,180	3,800	4,872	8,645	7,300
Maximum useable fuel subtracted.....	246	1,683	828	1,296	1,380	4,332	249	256	159	276	918	860	1,800	1,572	4,200	3,126
Maximum take-off payload.....	289	1,641	725	1,103	360	4,268	349	217	397	426	282	1,320	2,000	3,300	4,445	4,174
Nautical miles per hr (cruise speed).....	87	200	105	100	160	156	60	70	60	60	65	80	70	75	80	130
Lb fuel per hr (cruise speed) (max).....	60	750	144	198	216	1,680	84	84	92	100	270	377	515	510	1,320	1,600
Lb fuel for 50 nautical miles.....	35	188	69	99	68	358	70	60	77	84	208	235	368	340	825	615
Lb fuel for 100 nautical miles.....	70	376	138	198	136	1,076	140	120	154	168	416	470	736	680	1,650	1,230
Lb fuel for 200 nautical miles.....	140	752	276	396	272	2,152	280	240	308	336	832	940	1,472	1,360	3,300	2,460
<i>Computation for range vs payload 50 nautical miles</i>																
Maximum fuel load.....	246	1,683	828	1,296	1,380	4,332	249	246	159	276	918	860	1,800	1,572	4,200	3,126
Fuel for 50 NM subtracted.....	35	188	69	99	68	538	70	60	77	84	208	235	368	340	825	615
Lb avail for added payload (50 NM).....	211	1,495	759	1,197	1,312	3,794	179	186	82	192	710	625	1,432	1,232	3,375	2,511
Lb payload with full tanks added.....	289	1,641	725	1,103	360	4,268	349	217	397	426	282	1,320	2,000	3,300	4,445	4,174
Total payload for 50 NM.....	500	3,136	1,484	2,300	1,672	8,062	528	403	479	618	992	1,945	3,432	4,532	7,820	6,685
<i>100 nautical miles</i>																
Maximum fuel load.....	246	1,683	828	1,296	1,380	4,332	249	246	159	276	918	860	1,800	1,572	4,200	3,126
Fuel for 100 NM subtracted.....	70	376	138	198	136	1,076	140	120	154	168	416	470	736	680	1,650	1,230
Lb avail for added payload (100 NM).....	176	1,307	690	1,098	1,244	3,256	109	126	5	108	502	390	1,064	892	2,550	1,896
Lb payload with full tanks added.....	289	1,641	725	1,103	360	4,268	349	217	397	426	282	1,320	2,000	3,300	4,445	4,174
Total payload for 100 NM.....	465	2,948	1,415	2,201	1,604	7,524	458	343	402	534	784	1,710	3,064	4,192	6,995	6,070
<i>200 Nautical miles</i>																
Maximum fuel load.....	246	1,683	828	1,296	1,380	4,332	-----	-----	-----	-----	-----	-----	1,800	-----	-----	3,126
Fuel for 200 NM subtracted.....	140	752	276	396	272	2,152	-----	-----	-----	-----	-----	-----	1,472	-----	-----	2,460
Lb avail for added payload (200 NM).....	106	931	552	900	1,108	2,180	-----	-----	-----	-----	-----	-----	328	-----	-----	666
Lb payload with full tanks added.....	389	1,641	725	1,103	360	4,268	-----	-----	-----	-----	-----	-----	2,000	-----	-----	4,174
Total payload for 200 NM.....	395	2,572	1,277	2,003	1,468	6,448	-----	-----	-----	-----	-----	-----	2,328	-----	-----	4,840
Maximum range with payload (with 30-minute fuel reserve).....	350	400	575	720	980	850	145	170	77	135	185	126	255	195	180	200

2.5 Air Force Transport Aircraft Characteristics

Use operational data shown below as a planning guide only. Changes in weather, altitude, humidity, and other conditions will cause the values to vary.

a. Passenger, Cargo Load, and Flight Capabilities.*

	(C-46F Com- mando)	C-47D (Sky- train)	C-54G (Sky- master)	C-74 (Globe- master)	C-97C (Strato- freighter)	C-118A (DC-6)	C-119G (Packet)	C-121A (Con- stellation)	C-121C (Con- stellation)	YC- 121F (Super- Con- stellation)	C-123B	C-124C (Globe- master II)	C-130A (Her- cules)	C-131A (Samar- itan)	Convair 880	C-133A (Cargo- master)	Boeing 707	DC-8	Electra 188
Personnel:																			
Crew, normal.....	4	6	5	9	5	4	5	6	4	5	2	5	4	2	5	4	4	-----	5
Paratroops.....		27					42					112	64						
Troops.....	50	27	49	125	130	76	62	21	72	106	61	200	92	37	109	128	162	176	88
Litters.....	24	24	36	116	79	60	35	14	47	73	50	127	74	27	-----	64			
Max range without pay- load:																			
Kilometers.....	3,150	2,540	6,680	10,050	7,140	7,780	3,890	6,670	6,860	5,100	3,100	7,970	5,190	3,430	4,820 +	8,110	8,380 +	9,180 +	4,460 +
Nautical miles.....	1,700	1,370	3,550	5,425	3,850	4,200	2,100	3,600	3,700	2,750	1,625	4,300	2,800	1,860	2,600 +	4,376	4,620 +	4,960 +	2,400 +
Max payload (lb).....	19,900	12,160	28,666	66,000	68,000	42,000	26,760	16,500	31,640	34,400	24,400	76,486	35,000	7,100	34,900	115,418	42,000	35,680	26,600
Avg payload (lb) vs range :																			
Nautical miles																			
500	8,000	9,500	19,265	55,586	46,000		18,000	16,000	22,500	28,800	19,125	56,286	35,000	7,100	(*)	95,418	(*)	(*)	(*)
1,000	17,500	11,400	28,565	65,000	67,600	42,000	23,250	16,500	31,640	34,400	21,800	76,486				115,418			
1,500	5,870	7,800	19,265	55,000	46,000		15,250	15,750	22,500	28,800	16,000	55,000	35,000	7,100		95,418			
2,000	14,750	9,800	28,566	59,000	67,500	42,000	19,500	16,500	31,640	34,400	18,200	76,486				115,418			
2,500	3,625		16,500	48,000	44,000		11,750	15,500	22,500	28,800	3,750	47,000	35,000	7,100					
3,000	7,500		27,300	52,500	64,000	42,000	15,250	16,500	31,640	34,400	3,000	69,000				101,000			
3,500			24,000	46,000	56,000	41,000	3,250	12,750	22,500	25,200		38,000	32,500			81,000			
4,000			10,100	36,000	31,000			16,500	31,640	34,400		60,000				88,000			
4,500			20,800	40,000	49,000	35,000		8,000	19,000	16,000		32,000	16,250			68,000			
5,000			7,600	30,000	24,500			4,000	14,600			52,000				74,000			
5,500			11,500	34,000	29,000	24,500		8,000	27,400			44,000				61,000			
			1,000	24,000	9,000			600	7,400			17,500				42,000			
			1,200	28,000	10,000	14,000		1,250	9,200			27,000				48,000			
				18,000								9,000				22,000			
				22,000		3,000						9,000				22,000			
				13,000															
				17,000															
				8,000															
				12,000															
Cruise speed ¹ :																			
Knots.....	148	146	161	178	210	231	154	190	217	314	138	194	294	285	534	285	525	512	351
Miles per hour.....	170	168	186	205	242	266	177	219	250	362	159	223	339	328	615	328	605	689	405
Kilometers per hour..	275	271	299	330	390	428	286	352	403	583	256	360	545	529	990	629	974	949	651
Take-off distance at sea level ² :																			
Feet.....	1,750- 2,700	1,650- 2,900	1,400- 2,780	1,950- 3,400	2,700- 6,600	2,670- 6,050	1,820- 3,180	2,550- 3,000	2,500- 3,390	2,275- 3,840	350- 1,225	3,000- 5,520	1,410- 2,540	1,830- 2,880	7,000	3,800- 6,050	8,600	8,410	5,820

Meters-----	533- 822	473- 884	426- 848	594- 1,035	822- 1,980	813- 1,540	555- 969	777- 914	762- 1,035	692- 1,170	107- 373	914- 1,680	430- 774	558- 878	2,130	1,160- 1,850	2,620	2,560	1,770
Landing distance at sea level ^d :																			
Feet-----	1,300- 1,770	1,400- 2,040	1,525- 1,918	2,025- 2,400	2,880- 3,460	1,585- 2,750	1,764- 2,236	1,920- 1,950	2,375- 2,630	1,370- 2,140	538- 1,075	2,750- 3,250	1,370- 1,555	2,855- 3,460	3,500		6,400	4,110	4,960
Meters-----	396- 540	426- 622	464- 585	617- 732	878- 1,055	483- 839	538- 681	586- 594	722- 802	418- 652	164- 328	839- 990	418- 474	870- 1,055	1,065		1,950	1,252	1,510

^a Some aircraft, no longer standard in the U. S. Air Force, are shown because they are in use by one or more allied nations.

^b Upper figure represents normal operation; bottom figure represents overload.

^c Primarily passenger-type aircraft.

^d Variable, depending on load, headwind, altitude, temperature, etc. Average cruising speed is shown.

b. Cargo Loading and Lashing.

	C-46F	C-47D	C-54G	C-74	C-97C	C-118A	C-119G	C-121A	C-121C	YC-121F	C-123B	C-124C	C-130A	C-131A	Convair 880	C-133A	Boeing 707	DC-8	Electra 188
Typical load ^a :																			
Truck, ¼ T, 4x4-----	2		2	10	2											16			
Tlr, ¼ T-----		1	2																
105mm how, M3-----		1																	
Logistics cargo (lb)-----																			4,000
Truck, ¾ T, 4x4-----					2						2		1						
Truck, 2½ T, 6x6, M34-----							1					3							
Misc baggage (lb)-----						5,016		924		7,000					5,800		7,300	7,800	29,00
Passengers (VIP)-----								14											44
Passengers (1st class)-----															88		110	118	
Passengers (tourist)-----						76				106									
Litters-----									47					27					
Floor loading limitations (psi)-----															(b)		(b)	(b)	(b)
Main floor-----		0.87	1.4	0.72	1.4		1.4				1.4	1.4	7.5			2.08			
Auxiliary floor-----					0.7							0.3							
Treadway-----											48	30-50							
Floor outside treadways-----												30							
Inner walkway-----											31.2								
Outer walkway-----											15.6								
Ramp-----												30-50							
Tiedown fittings (lb) ^c :																			
500-----		6																	
700-----	14																		
1,125-----	8			18															
1,250-----					338		78												
1,500-----		6																	
1,750-----																			
1,900-----			(d)	38															
2,000-----			132																
2,175-----			(d)																
2,500-----	20		39																
3,900-----												10*							
4,250-----				8															
5,000-----							8				8		35			92			
7,000-----							15												
9,100-----												10*							
10,000-----							55				94		177			381			

See footnotes on page 30.

	C-46F	C-47D	C-54G	C-74	C-97C	C-118A	C-119G	C-121A	C-121C	YC-121F	C-123B	C-124C	C-180A	C-181A	Convair 880	C-183A	Boeing 707	DC-8	Electra 188
13,000.....	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	44 ^a	-----	-----	-----	-----	-----	-----	-----
20,000.....	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	4 ^f	-----	-----	-----	-----	-----	-----	-----
25,000.....	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	10	-----	-----	24	-----	-----	-----
30,000.....	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3 ^g	-----	-----	-----	-----	-----	-----	-----
35,000.....	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	16 ^b	-----	-----	-----	24	-----	-----	-----
40,000.....	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2 ⁱ	-----	-----	-----	-----	-----	-----	-----
50,000.....	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	4 ^b	-----	-----	-----	-----	-----	-----	-----
Restraint safety factors ¹ :																			
Forward.....	4	4	2	4	4	-----	4.5	-----	-----	-----	8	3	8	-----	-----	3	-----	-----	-----
Rearward.....	2	2	2	2	2	-----	1.5	-----	-----	-----	2	1.5	2	-----	-----	1.5	-----	-----	-----
Vertical.....	2.25	2.25	3	2.25	2.25	-----	2.25	-----	-----	-----	4.5	3	2	-----	-----	3	-----	-----	-----
Sideward.....	1	1	1	1.5	1.5	-----	1.5	-----	-----	-----	1.5	1.5	1.5	-----	-----	1.5	-----	-----	-----

^a One typical load is shown. The planner can vary these loads with combinations of other vehicles and/or equipment having similar weight and configuration. Cargo having dimensions which approach cargo-door dimensions should be measured carefully. A 5-inch clearance should be allowed for cargo that may have to be put through the door at an angle because of ramp loading. See paragraph 2.6 for door dimensions.

^b Primarily passenger-type aircraft.

^c Unless noted otherwise, thrusts may be applied in any direction.

^d At 45° angle.

^e Vertical.

^f Forward or aft.

^g Forward.

^h Vertical or sideward.

ⁱ Aft.

^j To determine the number of lashings required to secure a piece of cargo with a prescribed angle of tie against one thrust direction, complete the following relationship:

$$\text{Number of lashings} = \frac{\text{Weight of cargo in pounds} \times \text{restraint safety factor} \times 100}{\text{Tensile strength of lashing in pounds} \times \text{percent effectiveness of the system}}$$

c. Weight and Balance Factors.

	C-46F	C-47D	C-54G	C-74	C-97C	C-118A	C-119G	C-121A	C-121C	YC-121F	C-123B	C-124C	C-130A	C-131A	Convair 880	C-183A	Boeing 707	DC-8	Electra 188
Basic wt (lb).....	31,600	18,185	39,400	89,339	78,250	59,084	41,170	63,976	75,132	74,681	31,218	103,014	59,328	28,538	-----	117,000	-----	130,092	57,000
Normal max gross wt (lb).....	45,000	31,000	69,000	165,000	150,000	107,000	68,300	102,000	133,000	150,000	56,100	185,000	124,200	46,955	189,500	275,000	296,000	287,500	113,000
Emergency max gross wt (lb).....	55,000	33,000	73,000	170,000	175,000	129,400	72,700	107,000	145,000	167,875	58,800	216,400	-----	-----	-----	282,000	-----	-----	-----
Max landing wt (lb).....	55,000	33,000	73,000	160,000	160,000	108,000	72,700	89,500	122,000	125,000	-----	168,000	124,200	41,500	145,000	245,000	195,000	194,000	95,650
Center of gravity ^a :																			
Max forward.....	309	239.6	382	549	513	-----	318	-----	-----	-----	323	556.5	-----	-----	-----	-----	-----	-----	-----
Desirable.....	316	256.2	397	564	534	-----	330	-----	-----	-----	335	572	-----	-----	-----	-----	-----	-----	-----
Max aft.....	331	263.1	407	584	540	-----	335	-----	-----	-----	351	588	-----	-----	-----	-----	-----	-----	-----

^a Shown in inches from the reference datum line.

2.6 Air Force Transport Cargo Capacities

a. C-46F (Commando).

- (1) *Main compartment.* Length—48 ft.; width—9.8 ft.; height—7 ft.
- (2) *Belly cargo compartments.* Forward—3,450 lb.; aft, 3,000 lb.
- (3) *Main loading door.* Height—6.8 ft.; width—8.1 ft.; height from ground—8 ft.
- (4) *Special loading equipment.*
 - (a) Loading platform (part of floor extending beyond door).
 - (b) Two loading ramps.

b. C-47D (Skytrain) (Navy Equivalent: R4D).

- (1) *Cargo compartment.* Length—30.1 ft.; width—7.4 ft.; height—6.4 ft.; floor bearing strength—125 lb./sq. ft.
- (2) *Main loading door.* Height forward—5.9 ft.; height aft—4.6 ft.; width—7 ft.; height from ground—4.7 ft.
- (3) *Special loading equipment.* Sectionalized loading ramp with a loading platform.

c. C-54G (Skymaster) (Navy Equivalent: R-5D-5).

- (1) *Main compartment.* Length—49.7 ft.; width—8.6 ft.; height—7.8 ft.; floor bearing strength—200 lb./sq. ft.
- (2) *Cargo sections.*

Designation	Width (in.)	Length (in.)	Cargo capacity (cu ft)
C	103.2	59.5	155.1
D	103.2	61.0	156.2
E	103.2	58.5	153.4
F	103.2	61.5	159.9
G	103.2	59.0	154.8
H	103.0	61.0	156.0
I	101.0	59.375	153.3
J	101.0	61.625	78.3 ¹
K	92.8	64.125	68.1 ¹

¹ Reduced capacity caused by reserving left half of cargo section for passageway and life-raft storage.

- (3) *Belly cargo compartments.* Forward—126 cu. ft.; aft—126 cu. ft.
- (4) *Main loading door.* Height—5.6 ft.; width—7.9 ft.; height above ground—8.8 ft.
- (5) *Special loading equipment.* Cargo hoist, 2,000-lb. cap.

d. C-74 (Globemaster).

- (1) *Main compartment.* Length—71.4 ft.; width—11.1 ft.; height—8.3 ft.; floor bearing strength—104 lb./sq. ft.
- (2) *Main loading door.* Length—10.4 ft.; height—10 ft.; height from ground—11.9 ft.

- (3) *Lower cargo compartments.* Total cube—816 cu. ft.; maximum load density—14 lb./cu. ft.
- (4) *Belly loading doors.* Width—40 in.; depth—35 in.
- (5) *Cargo loading well.* Length—12.9 ft.; width—7.1 ft.
- (6) *Special loading equipment.*

- (a) One fixed hoist and two traveling crane hoists (each 8,000 lb. cap.) in main cargo compartment.
- (b) Loading platform that can be used as elevator.

e. C-97C (Stratofreighter).

- (1) *Main compartment.* Cu. ft.—4,309; sq. ft.—559.
- (2) *Lower compartment.* Cu. ft.—1,618; sq. ft.—222.
- (3) *Treadways (single-axle load).* Capacity—12,700 lb.
- (4) *Electric hoist capacity.* With snatch block—5,000 lb.; with hoisting hook—2,500 lb..
- (5) *Loading ramp capacity.* On each of 2 treads—12,700 lb.
- (6) *Floor bearing strength.* Main deck—200 lb./sq. ft.; lower deck—100 lb./sq. ft.
- (7) *Clearances.*

- (a) *Main cabin.* Height—8 ft.; length—63.6 ft.; width at floor level—8.8 ft.
- (b) *Main loading door.* Length—14.3 ft.; width (fore/aft)—9.3 ft./6.4 ft.; height from ground (fore/aft)—7.8 ft./9.6 ft.
- (c) *Cargo door.* Height—6.5 ft.; width—6.7 ft.

(8) Special loading equipment.

- (a) Folding ramp.
- (b) Monorail loading system, including power hoist. (Eighty-five 300-lb. or fifteen 1,500-lb. A-22 containers.)
- (c) Floor-level conveyors: drop capacity limited only by allowable cargo load.

f. C-118A (Liftmaster) (Navy Equivalent: R6D).

- (1) *Main compartment.* Length—68 ft.; width at floor—8.75 ft.; height—7.75 ft.; volume—4,307 cu. ft.; floor area—558 sq. ft.
- (2) *Lower compartment.* Forward—213 cu. ft.; aft—247 cu. ft.
- (3) *Clearances.*
 - (a) *Main loading door.* Length—10.3 ft.; width—6.5 ft.; height above ground—8.9 ft.

- (b) *Forward loading door.* Length—7.6 ft.; width—5.6 ft.; height above ground—8.8 ft.
 - (c) *Lower cargo door.* Length—3.8 ft.; width—3.1 ft.
 - (4) *Special loading equipment.* Self-powered loading elevator (4,000-lb. cap.) may be attached to front or rear cargo door. Folds for storage.
- g. *C-119G (Packet) (Navy Equivalent: R4Q-2).*
- (1) *Main compartment.* Maximum cube—3,150 cu. ft.; cube w/o cargo doors—2,850 cu. ft.; floor area—353 sq. ft.; floor bearing capacity—200 lb./sq. ft.; overall length—36.9 ft.; maximum width—9.8 ft.; minimum width—9.2 ft.; maximum height—8 ft.; height clear under trolley—7.7 ft.
 - (2) *Clearances.*
 - (a) *Main cargo door.* Height—8 ft.; maximum width—9.8 ft.; minimum width—9.2 ft.; height from ground—4 ft.
 - (b) *Jump doors.* Height—6 ft.; width—3 ft.
 - (3) *Special loading equipment.*
 - (a) Ramp (2 treadways).
 - (b) Jack posts to support rear of aircraft during loading.
 - (c) Swiveling hitch for block and tackle can be attached to floor at front or rear of cargo compartment.
 - (d) Floor roller at aft end of cargo compartment.
- h. *C-121C (Super Constellation) (Navy Equivalent: WV-2).*
- (1) *Main compartment.* Maximum cube—4,875 cu. ft.; minimum cube—3,031 cu. ft.; floor area—744 sq. ft.; overall length—83.3 ft.; width—11.6 ft.; height—6.7 ft.
 - (2) *Aft lower compartment.* 424 cu. ft.
 - (3) *Forward lower compartment.* 269 cu. ft.
 - (4) *Main cargo door.* Width—9.3 ft.; height—6.1 ft.
 - (5) *Forward cargo door.* Width—5.1 ft.
 - (6) *Special loading equipment.*
 - (a) Aerolift (cargo elevator).
 - (b) Litter lift.
 - (c) Pulley block (conveyor to move cargo within aircraft).
- i. *YC-121F (Super Star Constellation).* Capacities and cargo loading provisions are identical to those of the C-121C (h above) except that the cube of the aft lower compartment is 194 cu ft.
- j. *C-123B (Provider).*
- (1) *Main compartment.* Length—36.7 ft.; width—9.2 ft.; height—8.2 ft.; cubic feet—3,750; floor area—450 sq. ft.; floor bearing strength—200 lb./sq. ft.
 - (2) *Main cargo door.* Height—8.2 ft.; width—9.2 ft.; height from ground—2.6 ft.
 - (3) *Special loading equipment.*
 - (a) *Loading ramp.* Power operated. Can be positioned from ground to any truck-bed height.
 - (b) *Jacks.* Two jacks support rear of aircraft during loading.
 - (c) *Opening for winch cable.* This opening is located in nose of aircraft. To assist in loading, a truck winch cable can be threaded through this opening.
- k. *C-124C (Globemaster II).*
- (1) *Main compartment.* Useable height—11.5 ft.; overall length—77 ft.; width at floor level—11.3 ft.; cube—10,000 cu. ft.
 - (2) *Main loading door.* Height—11.6 ft.; top width—11.3 ft.; bottom width—8.9 ft.; height from ground—8.2 ft.
 - (3) *Elevator well.* Length—13.3 ft.; width—7.7 ft.; ground to fuselage—13 ft.
 - (4) *Floor load capacity.* Main deck—183 lb/sq. ft.; second deck—43 lb./sq. ft.; treadway area—4,300–7,200 lb./sq. ft.
 - (5) *Special loading equipment.*
 - (a) *Ramp.* Loading incline—17°; single-axle load—20,000 lb.; 2 treadways, each with capacity of 10,000-lb. wheel load.
 - (b) *Elevator hoist.* Capacity—9,300 lb.
 - (c) *Traveling hoists.* Two, each with 8,000-lb. lift capacity, mounted on overhead rails in cargo compartment.
 - (d) *Loading pulleys.* Capacity of 40,000 lb. Located at aft fuselage.
- l. *C-130A (Hercules).*
- (1) *Main compartment.* Length—41.5 ft.; width—10.3 ft.; height—9.1 ft.; cube—3,870 cu. ft.
 - (2) *Main loading door.* Width—10 ft.; height—9.2 ft.; height from ground—3.75 ft.
 - (3) *Side cargo door.* Width—7.25 ft.; height—6 ft.; height from ground—3.4 ft.
 - (4) *Jump door.* Width—3 ft.; height—6 ft.; height from ground—3.4 ft.

(5) *Cargo floor capacity.*

- (a) Between stations 337 and 682: single-axle load—13,000 lb.; single-wheel load—6,500 lb.; bearing surface—1,080 lb./sq. ft.
- (b) Forward of station 337, aft of station 682, including ramp: single-axle load—6,000 lb.; single-wheel load—3,000 lb.

(6) *Special loading equipment.*

- (a) *Ramp.* Single-axle load—13,000 lb.; single-wheel load—6,500 lb.
- (b) *Loading pulley and winch.* 25,000-lb. capacity.
- (c) *Roller conveyors.*

m. *C-133A (Cargomaster).*

- (1) *Main compartment.* Length—97.3 ft.; width (2 in. above floor)—12 ft.; width (floor level)—11.85 ft.; useable height—

12 ft.; height under rear spar—12 ft.; maximum single-axle capacity—20,000 lb.; maximum dual-axle capacity—44,000 lb.; maximum track capacity—76,000 lb.; total cube—13,028 cu. ft.; floor bearing capacity—300 lb/sq. ft.

- (2) *Rear loading door.* Height—12.7 ft.; width—12.1 ft.; height above ground—4.2 ft.

- (3) *Side loading door.* Height—8.3 ft.; width—8.8 ft.; height above ground—4.2 ft.

(4) *Special loading equipment.*

- (a) *Ramp.* Hydraulically operated and integral with rear loading door; 9° ramp incline; 15° toe incline.
- (b) *Loading sheaves.* Cable loads up to 20,000 lb.
- (c) *Portable electric winch.* Cable loads up to 15,000 lb.

Section III. OPERATIONS

2.7 Outline Standing Operating Procedure for Air Movements

a. *General.* Amplification of command policies on use of air transportation (intratheater and intertheater), including responsibilities, utilization, and procedures in the employment of organic aviation units; responsibilities for coordination with Air Force aerial ports.

- (1) *Submission of requirements.* Responsibilities for, timing, format, procedures, and policies affecting submission of advance and firm requirements for air movement of supplies and personnel.
- (2) *Air tonnage allocations.* Controlling agency; procedures for application, allocation, and use of allocations; formats.
- (3) *Air priorities system.* Controlling agency; procedures and responsibilities for application, determination, dissemination, and use of priorities; implementation of command policies and directives.
- (4) *Aerial port calls.* Responsibilities and procedures for the issue of port calls for supply and personnel movements, implementation and execution of such calls.
- (5) *Special movement control actions.* Special actions required to integrate movement control of air transportation with other applicable modes of transportation.
- (6) *Loading and unloading of aircraft.* Policies, responsibilities, and procedures for

loading and unloading troops, accompanied supplies, and equipment at aerial ports.

- (7) *Diversions and reassignments.* Authority, procedures, and channels prescribed for effecting and executing diversions or reassignments.

b. *Supply Movements.*

- (1) *Designation for air movement.* Authority for, responsibilities, how accomplished and disseminated, actions to be taken.
- (2) *Special packing requirements.* Special instructions for packing or preparing supplies for air movement. Responsibility for packing and inspecting before air movement.
- (3) *Special marking.* Types, responsibilities for applying marking on containers and for obliterating old markings.
- (4) *Documentation.* Responsibilities and procedures for preparing and distributing established documents.
- (5) *Airdrops.* Amplification of command policies and directives on packaging and delivery responsibilities, methods and procedures for obtaining and accomplishing airdrops, methods and responsibilities for marking landing or drop zones.
- (6) *Records and reports.* Responsibilities and methods of maintenance of specific

records, and reference to reports to be submitted.

c. Personnel Movements.

- (1) *Preparation for air movement.* Command policies and directives on procedures and requirements for preparing units and individuals for air movement.
- (2) *Movement to aerial ports.* Procedures and responsibilities for the movement of units and individuals to aerial ports for air movement.
- (3) *Documentation.* Preparation, distribution, and uses of established flight forms and documentation.
- (4) *Records and reports.* Responsibilities and methods for maintenance of specific records, and reference to reports to be submitted.

2.8 Outline Standing Operating Procedure for Air Transport Service (Air Force and Army Aviation)

a. General. Policies involved in control, operation, and maintenance of facilities, equipment, and installations; command responsibility; technical supervision required and agencies involved; responsibility for operational control.

b. Mission. Service to be provided by organic aviation units when made available for administrative movements, Air Force troop carrier units, and other aircraft in direct support; extent of operation.

c. Functions.

- (1) Scheduled and nonscheduled operations.
- (2) Maintenance of equipment: responsibilities, procedures, facilities, inspections.

d. Operational Planning. Personnel, equipment, and supply requirements; capabilities and capacities; communication procedures.

e. Operations. Operational procedures and control; utilization of personnel, equipment, and facilities; priorities; coordination; documentation; records and reports; service to be given personnel and cargo; liaison established between aviation and user units.

f. Maintenance. Responsibilities and procedures for maintenance, regulations, reports, and records.

g. Supply. Responsibilities, authorized levels, procedures, and accounting methods for the Air Force.

h. Intelligence. Responsibility for collection,

collation, evaluation, and dissemination of air transportation intelligence.

i. Security. Responsibilities, disaster and defense plans, and equipment and supply security.

j. Records and Reports. Responsibilities: technical, operational, personnel, and stock records and reports.

k. Training. Responsibilities: unit and technical training.

2.9 Weight and Balance Terms

a. Aircraft Balance Limits. The maximum forward and maximum aft permissible locations of the aircraft center of gravity expressed as station numbers or as percentages of the mean aerodynamic chord (MAC). If these limits are exceeded, the aircraft will have unsatisfactory flight characteristics.

b. Center of Gravity (CG). The point about which an object would balance if supported at that point; or the point at which the weight of an object or group of objects can be considered concentrated.

c. Reference Datum Line (RDL). An imaginary vertical line at or near the nose of the aircraft from which all horizontal distances are measured. Aircraft diagrams show this line as structural station zero.

d. Station Number. A number, generally marked on the interior of an aircraft, indicating a plane extending across the fuselage of the aircraft parallel to the reference datum line and representing the distance from it in inches.

e. Arm. The horizontal distance in inches from the reference datum line to the center of gravity of an object.

f. Moment. The product of a quantity multiplied by its arm. Moments may be expressed in inch-pounds or foot-pounds; for example, 2 pounds (weight) $\times$ 10 inches (arm) = 20 inch-pounds (moment).

g. Allowable Cargo Load. The amount of cargo and troops, determined by weight, cubic displacement, and distances to be flown, which may be transported by aircraft.

h. Basic Weight. The weight of the aircraft, including its operating equipment and trapped fuel and oils, but excluding crew, oil, fuel, and cargo. The basic weight varies with modifications and changes in operating equipment.

i. Operating Weight. Basic weight of the aircraft plus minimum crew but excluding fuel and cargo.

j. *Ready-for-Loading Weight.* Total aircraft, crew, oil, and fuel weight; or the gross weight less cargo; or the basic weight plus crew, oil, and fuel.

k. *Normal (Design) Gross Weight.* The gross weight on which the aircraft design is based. It is the maximum weight at which the aircraft can be flown and still not exceed the load and safety factors established by design specifications.

l. *Maximum (Alternate) Gross Weight.* A gross weight in excess of the design gross weight. The maximum alternate gross weight is normally used in combat operations, but does not afford any margin of safety.

2.10 Calculating Safe Placement of Aircraft Loads

a. The general rules for determining the placement of a given load so as to cause the center of gravity of the aircraft to fall within safe limits are as follows:

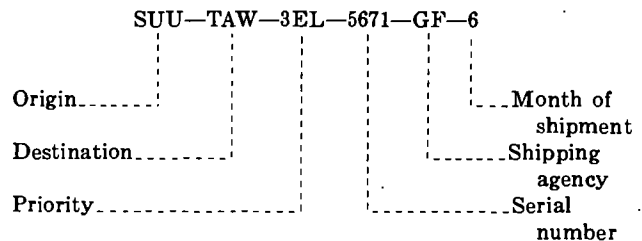
- (1) Establish a reference datum line.
- (2) Determine the center of gravity of each item involved in the loading. This will be required for computations in (7) below. Calculate the movement for each item.
- (3) Select from design data the desirable center of gravity at which the loaded aircraft should balance.
- (4) Compute the desired load moment (the ready-for-loading weight of the aircraft and its load multiplied by the distance between the desirable center of gravity and the reference datum line).
- (5) Subtract the moment of the ready-for-loading aircraft from the moment of the loaded aircraft.
- (6) Obtain the arm (station number) at which to place the load in the aircraft, by dividing the weight of the load into the difference between the gross moment and the ready-for-loading moment.
- (7) The arm thus obtained will apply to the point at which the load is concentrated. It must be borne in mind that for multiple-piece loads the moment which applies to the point of load concentration is equal to the sum of the moments for each piece.
- (8) Verify that the load will fit into the aircraft at the desired station.

b. For accurate weight and balance determina-

tion, see the -10 manual of the TM 55- series for the appropriate aircraft.

2.11 Air Movement Designator

This combination of code letters and numbers is assigned by the issuing agency to identify and indicate precedence of traffic movement within each service's allocation (AR 59-8 and par. 7.17). Each air movement designator consists of code symbols in sequence as shown in the following example and as explained below.



Type of Traffic

a. *SUU*—Indicates the MATS airport of origin of the traffic; in this example, "Travis AFB."

b. *TAW*—Indicates the MATS airport of destination of the traffic; in this example, "Tachikawa."

c. *3*—Indicates the priority assigned to the traffic movement; in this example, "Priority 3" (par. 2.12).

d. *EL*—Indicates the type of traffic (i.e., whether passenger or cargo moved; in this example, "Passenger—Emergency leave").

e. *5671*—Indicates the traffic movement serial number assigned by the issuing agency; in this example, "Movement No. 5671." (These numbers are issued consecutively, from 0001 through 9999, after which the issuing agency begins again with 0001.)

f. *GF*—Indicates the sponsoring department in whose interest the traffic is being moved; in this example, "The Department of the Army."

g. *6*—Indicates the month in which the traffic is to be moved; in this example, "June."

2.12 Cargo Priorities

Number	Type	Description
1	Emergency.....	Need so acute that precedence should be given over all other traffic.
2	Urgent.....	Essential to national security.
3	Important.....	Necessary in interest of national security.
4	Qualifies.....	Qualifies for air transportation.

2.13 Lashing Terms

a. *Applied Load.* The total stress or load imposed upon one cargo tiedown fitting. The applied load equals the tensile strength of all the cargo tiedown devices attached to one cargo tiedown fitting.

b. *Cargo Tiedown Pattern.* The location and spacing of the cargo tiedown fittings in the floor, ceiling, or walls of an aircraft.

c. *Load Spreader.* Wooden planks or similar material placed on the cargo compartment flooring of an aircraft to distribute the load reactions of the cargo over a greater area and reduce the floor bearing pressure.

d. *Rated Strength.* The safe-load capacity of a cargo tiedown fitting or lashing with an applied safety factor. In many cases, the rated strength of a cargo tiedown fitting is restricted by the angle of application of the load.

2.14 Lashing Strengths

All lashings should be secured at an angle of 45° with the cargo floor and 45° in the direction of expected thrust (fig. 2.16) or with the long axis of the cargo compartment, except for assault-type aircraft. Cargo in the C-123 and C-130 aircraft should be secured at an angle of 30° with the cargo floor and 30° in the direction of the expected thrust. The strength of tiedown fittings must be kept in mind. The strongest lashing is no stronger than the fitting to which it is attached. *If a lashing is stretched to its breaking point, the fitting is*

stressed an amount equal to the *full tensile strength* of the lashing.

a. Flexible lashings secured at angles of 45° with the cargo floor and in the direction of expected thrust will hold approximately 70 percent of their rated tensile strength against forward and rearward thrusts, 70 percent of their rated tensile strength against vertical thrusts, and 0 percent of their rated tensile strength against sideward thrusts.

b. Flexible lashings secured at angles of 45° with the cargo floor and 45° with the main axis of the cargo compartment will hold approximately 50 percent of their rated tensile strength against forward or rearward thrusts, 50 percent of their rated tensile strength against sideward thrusts, and 70 percent of their rated tensile strength against vertical thrusts. In this type of lashing arrangement, only the lashings for forward and rearward thrusts need be computed. The lashings used to hold the equipment against forward and rearward thrusts are more than enough to secure the load against sideward and vertical thrusts.

c. Flexible lashings secured at angles of 30° with the cargo floor and 30° with the main axis of the cargo compartment will hold approximately 75 percent of their rated tensile strength against forward and rearward thrusts, 43 percent of their rated tensile strength against sideward thrusts, and 50 percent of their rated tensile strength against vertical thrusts.

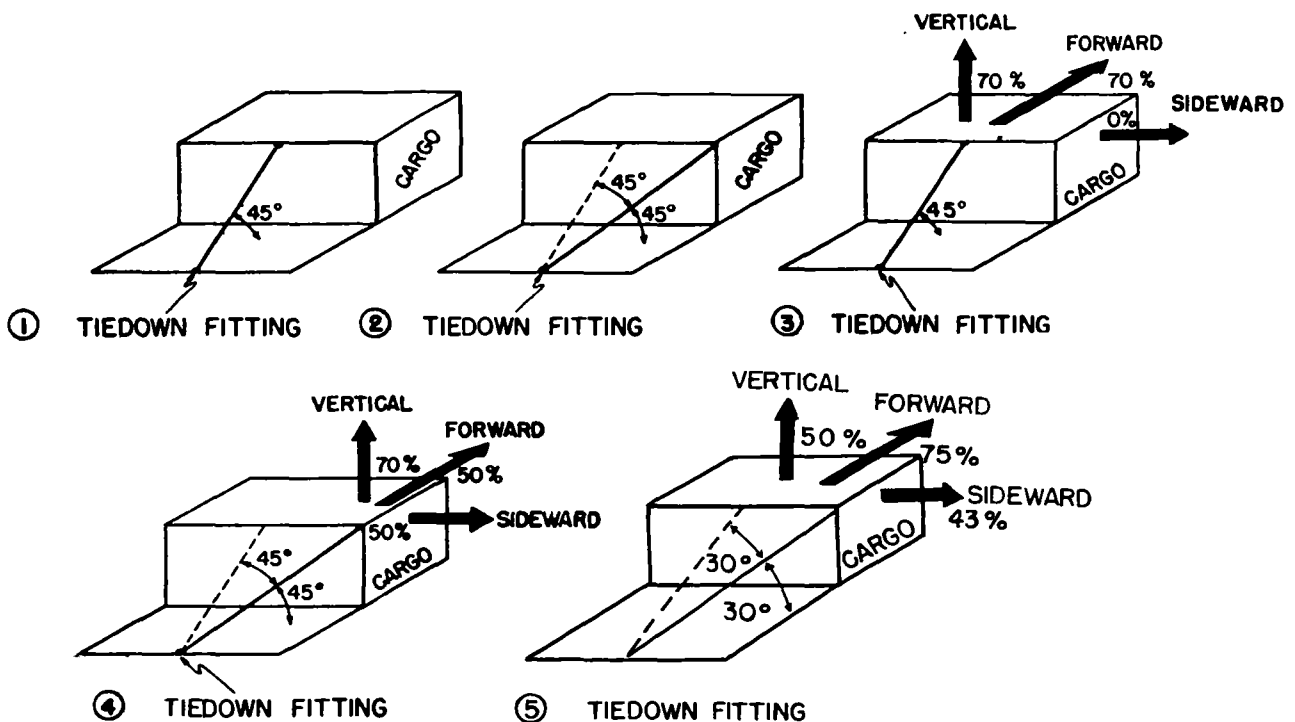


Figure 2.16. Lashings at 45° and 30° angles.

percent of their rated tensile strength against forward and rearward thrust, 50 percent of their rated tensile strength against vertical thrust, and 43 percent of their rated tensile strength against sideward thrust. Lashings computed at 30° angles need only be computed for sideward thrust be-

cause the lashings used to hold the equipment against sideward thrust are enough to secure the load against forward, rearward, and vertical thrusts.

d. For a further discussion of loading and lashing, see TM 57-210.

2.15 Lashing Constants and Formulas

a. Restraint Constants Per 1,000 Pounds of Cargo.

Strength of tiedown system	Angle of tie								
	45°-45°							30°-30°	
	Restraint safety factors							Restraint safety factors	
	1.5G	2.0G	2.25G	3.0G	4.0G	4.5G	8.0G	2.0G	8.0G
25,000-lb (D-1 or MB-2 device).									
25,000-lb fitting-----	0.12	0.16	0.18	0.24	0.32	0.36	0.64	0.11	0.43
10,000-lb (C-2 or MB-1 device).									
10,000-lb fitting-----	.3	.4	.5	.6	.8	.9	1.6	.27	1.1
7,000-lb (C-2 or MB-1 device).									
7,000-lb fitting-----	.5	.6	.7	.9	1.2	1.3	2.3	3.82	15.3
5,000-lb (B-1 or MC-1 device).									
5,000-lb fitting-----	.6	.8	.9	1.2	1.6	1.8	3.2	.53	2.1
2,000-lb (½-in. rope).									
5,000-lb fitting-----	1.5	2.0	2.3	3.0	4.0	4.5	8.0	1.3	5.3
1,250-lb (A-1 device).									
1,250-lb fitting-----	2.4	3.2	3.6	4.8	6.4	7.2	12.8	2.14	8.54
1,150-lb device and fitting-----	2.7	3.5	4.0	5.3	7.0	7.9	14.0	2.33	9.28

This table was derived for forward and rearward thrusts from the formula:

$$K = \frac{1,000 \times G \times 100}{R \times E}$$

where

K = constant per 1,000 lbs of load

G = number of G's involved (restraint safety factor)

R = rated tensile strength of lashing

E = percent effectiveness of lashing system (50 percent for 45°-45° angle and 75 percent for 30°-30° angle of tie)

b. Formula for Computing Number of Lashings Required.

$$\text{Number of lashings} = \frac{W \times K \text{ for 1 direction of thrust}}{1,000}$$

where K = constant from table above

W = weight of cargo in pounds

2.16 Tiedown Devices

The following table gives the number of tiedown devices, by type, which the Air Force will furnish on each aircraft listed:

Type	C-46, C-47	C-54	C-74	C-97	C-119	C-121	C-123	C-124	C-130A, C-130B	C-133A
Tiedown cargo strap A1A, 1,250-lb cap-----	15	40	60	60	25	25	20	60	10	0
Tiedown cable B-1, 5,000-lb cap--	5	5	15	12	10	5	10	50	0	0
Tiedown chain C-2, 10,000-lb cap--	0	8	20	20	28	0	35	24	24	(*)
Tiedown chain D-1, 25,000-lb cap--	0	0	0	0	0	0	0	24	14	(*)
Tiedown device MC-1, 5,000-lb cap--	0	0	0	0	0	0	0	0	10	(*)
Tiedown device MB-1, 10,000-lb cap--	0	0	0	0	0	0	0	0	24	(*)
Tiedown device MB-2, 25,000-lb cap--	0	0	0	0	0	0	0	0	14	0
Cargo net, steel cable, A2, 10,000-lb cap-----	0	0	0	0	0	0	0	0	3	0

* Must be requisitioned from Squadron Supply for each specific mission.

2.17 Typical Loads

See TM 57-210 or TM 1-series (-9 Loading Instruction) for the applicable aircraft for typical loads. One typical load is shown in paragraph 2.5.

2.18 Standard Parachutes and Carrying Capacities

Parachute	Diameter (ft)	Maximum load capability (lb)
G-1, G-1A.....	24	300
G-12.....	64	2,200
G-13.....	32.4	500
G-11, G-11A.....	100	3,500

2.19 Aerial Delivery Containers and Typical Loads

Container	Average safe load (lb)	Typical load
A-7A.....	100-500	Packaged nonfragile supplies
A-21.....	100-500	Fragile and nonfragile supplies
A-22.....	500-2,200	Fragile and nonfragile supplies

2.20 Loading or Unloading Time for Army Aircraft

a. Rotary-Wing Aircraft.

- (1) Troops—3 minutes.
- (2) Casualties—10 minutes.
- (3) Cargo, in fuselage—5 minutes.
- (4) Cargo, external load—30 seconds.
- (5) Refueling:
 - (a) Observation (OH-13 and OH-23)—7 minutes.
 - (b) Utility (UH-19 and UH-1)—10 minutes.
 - (c) Light transport (CH-21 and CH-34)—15 minutes.
 - (d) Medium transport (CH-37)—20 minutes.

b. Fixed-Wing Aircraft.

- (1) Troops—approximately 2 to 3 minutes, depending on aircraft.
- (2) Casualties—10 minutes.
- (3) Cargo, in fuselage.
 - (a) Load—10 to 30 minutes, depending on cargo.
 - (b) Unload—5 to 15 minutes.
- (4) Cargo, external load.
 - (a) Load—10 minutes.
 - (b) Air-landed—10 minutes.
 - (c) Parachute—30 seconds.
 - (d) Free fall—10 seconds.
- (5) Refueling.
 - (a) Observation, light (O-1)—5 minutes.
 - (b) Utility (U-6)—8 minutes.

(c) Transport (U-1A)—15 minutes.

(d) Staff transport (U-8)—10 minutes.

2.21 Maximum Ground Times for Air Force Aircraft

The following information may be used for general planning purposes:

a. *Cargo Flights.* Ground time at point of origin is 3 hours; 2 hours is time at en route bases. At destination bases where only off-loading is done, 2.5 hours is ground time.

Aircraft	On-load bases (hours)	Destination bases (off-loading and reloading hours)
C-54.....	2.5	3
C-97.....	4.5	6
C-119.....	2.5	3
C-123.....	2.5	3
C-124.....	4.5	6
C-130A & B.....	3.5	4
C-133A.....	4.0	5

b. *Passenger Flights.* Air Force aircraft have maximum ground times of 2.5 hours at on-load bases and 3 hours at destination bases for off-loading and reloading.

2.22 Aircraft Landing Sites

See FM 57-35, FM 1-100, and TM 5-251.

2.23 Estimating Army Aircraft Movement Capability

a. *General.* To assess capability to move personnel and supplies by Army aircraft, the analyst must make certain assumptions and consider the various factors involved. Some or all of the factors will apply to a particular problem, depending primarily upon the type of aircraft employed. Helicopters, although inferior to fixed-wing aircraft in speed and range, are especially valuable because of landing, takeoff, and hovering capabilities. They can operate in areas that are inaccessible to fixed-wing aircraft and be loaded and unloaded in less time than fixed-wing aircraft. On the other hand, fixed-wing aircraft can generally operate more hours per day with a higher sustained availability. Assumptions, factors involved, and methods of making capability estimates are given below.

b. Assumptions.

- (1) Air and ground crews are proficient.
- (2) Adequate landing and takeoff sites are available.
- (3) Ground handling equipment is adequate.
- (4) Aircraft are used only on tactical missions.

c. *Factors Involved.* Depending upon the nature of a particular mission, the analyst must consider the following:

- (1) *Type and number of aircraft involved.*
- (2) *Loading.*
 - (a) Weight of cargo and lift capability (payload) of aircraft.
 - (b) Configuration of cargo in relation to size of cargo compartment and cargo compartment doors.
 - (c) Sling loads for helicopters.
 - (d) Wing loads for fixed-wing aircraft.
- (3) *Hours of daily operation (flying hours).*
 - (a) Helicopters—4
 - (b) Fixed-wing aircraft—6
- (4) *Miles in the hour.* Speed plus loading, unloading, and flying time will determine miles in the hour. Operational hours and distance can then be used to compute the number of round trips each aircraft can make. The average loading and unloading times are shown below.

	Helicopter Load or unload (min.)	Fixed-wing aircraft Load (min.)	Unload (min.)
Troop.....	3	2-3	1
Casualties.....	10	10	10
Cargo inside.....	5	10-30	5-15
Cargo on slings.....	0.5	---	---
Wing loads.....	---	10	10

- (5) *Daily round trips per aircraft.* This is obtained by multiplying operating hours by miles in the hour and dividing the product by distance.
- (6) *Availability.* Availability is affected by the adequacy and efficiency of maintenance and supply and by the relative location of operating and service units. The average availability of aircraft on hand for sustained and short-term operations is shown below.

	Sustained (percent)	Short-term (percent)
Helicopters.....	67	90
Fixed-wing aircraft.....	75	90

- (7) *Aircraft requirement.* The aircraft required to accomplish a mission is determined by two factors—the basic requirement and the type of operation.
 - (a) *Basic.* The number of aircraft needed to meet the basic requirement is obtained by dividing the total tonnage to be moved by the payload of one aircraft of the type to be used in the operation.

- (b) *Type of operation.* The basic aircraft requirement figure has to be adjusted according to the variable factors involved. The most common variable factors are as follows:

1. *Distance.* Distance causes the fuel and payload relationship to vary inversely. When the operation exceeds 50 miles (80 kilometers), the basic aircraft requirement should be increased approximately 7 percent for each 20-mile (32-kilometer) increment.
2. *Sustained operation.* In a sustained operation, the basic number of aircraft required should be increased by 50 percent.
3. *Combat loading.* A 10-percent increase of the basic requirement is necessary for combat loading.
4. *Miscellaneous variables.* As altitude and/or temperature increase, the aircraft requirement will also increase because of a decrease in weight-lifting capability. Humidity and other weather conditions also affect the aircraft requirement. The analyst must determine the adjustments to be made because of these variables.

d. *Making the Estimate.* When estimating the aircraft requirement or the tons that can be moved daily by aircraft, use the formula below.

- (1) *Formula.*

$$A = B \times C \times D$$

where

- A = daily tonnage capability
- B = daily round trips flown per aircraft
- C = payload of one aircraft
- D = aircraft employed

- (2) *Movement by helicopter.*

- (a) *Problem.*

What is the daily lift capacity of 25 helicopters in the communications zone where—

- 4 = operational hours
- 90 = average speed in miles in the hour (includes loading and unloading time)
- = 144.8 kilometers in the hour
- 75 = round-trip distance in miles
- = 120.7 kilometers

90 = percent of aircraft available
 1.4 = short tons of payload for each aircraft
 0.9 = availability of 90 percent

(b) *Solution.*

$$B = \frac{4 \times 90 \text{ mih}}{75 \text{ miles}} \text{ or } \frac{4 \times 144.8 \text{ kmih}}{120.7 \text{ kilometers}} \\ = 5 \text{ round trips per aircraft}$$

$$A = 5 \times 1.4 \times 25 \times 0.9 = 157 \text{ short tons per day}$$

(3) *Movement by fixed-wing aircraft.*

(a) *Problem.*

What is the sustained fixed-wing aircraft requirement to move 500 short tons of cargo per day a distance of 35 miles (56.3 kilometers) under combat conditions where—
 1.1 = multiplier for combat loading

1.5 = multiplier for sustained operations
 1.4 = short tons of payload for each aircraft
 80 = average speed in miles in the hour (includes loading and unloading time)
 = 128.7 kilometers in the hour
 6 = operational hours per day

(b) *Solution.*

$$500 \times 1.1 = 550 \text{ (adjusted tonnage for combat loading)}$$

$$B = \frac{6 \times 80 \text{ mih}}{2 \times 35 \text{ miles}} \text{ or } \frac{6 \times 128.7 \text{ kmih}}{2 \times 56.3 \text{ kilometers}} \\ = 7 \text{ round trips per aircraft}$$

$$D = \frac{550 \times 1.5}{7 \times 1.4} = 84 \text{ aircraft for sustained operations}$$

Section IV. MAINTENANCE AND SUPPLY

2.24 Availability of Army Aircraft

Availability factors for Army aircraft are operational targets which will be revised as more experience is accumulated in aircraft operation, maintenance, and attendant availability factors. The appropriate supply bulletin (SB 1-1 and SB 1-2) should be consulted for the latest availability factors.

2.25 Maintenance Man-Hour Requirements Per Flying Hour

Maintenance man-hour requirements per flying hour are developed by the Chief of Transportation. These requirements are periodically revised, as more experience is accumulated in aircraft operation and maintenance. SB 1-2 should be consulted for the latest available maintenance man-hour requirements per flying hour and SB 1-1 should be consulted for the annual Army Aircraft Flying-Hour Program.

2.26 Direct Productive Maintenance Man-Hour Analysis for a Given Period

The following examples show a direct productive maintenance man-hour analysis for a given period (a period of 1 month is used for purposes of this manual):

a. Determination of man-hour requirement, where—

20 = number of aircraft

3 = organizational maintenance man-hours required to produce 1 flying hour

26 = monthly programmed flying hours

$20 \times 3 \times 26 = 1,560$ minimum maintenance man-hours required per month

b. Determination of maintenance man-hours available, where—

8 = number of direct maintenance personnel available

8 = hours per workday

20 = workdays per month

24 = percent of time off due to leave, KP, guard, sickness, etc. (based on local situation and specific period of time)

$8 \times 8 \times 20 = 1,280$ maintenance man-hours per month

$0.24 \times 1,280 = 307$ maintenance man-hours not available

$1,280 - 307 = 973$ maintenance man-hours available

c. Comparison of maintenance capability with maintenance workload, using results computed in a and b above.

$973 - 1,560 = -587$, which shows a deficit, or shortage, in the number of man-hours available

d. Computation of direct maintenance personnel requirements, using the following formula:

$$\text{Direct maintenance personnel required} = \frac{\text{No. of acft} \times \text{man-hours per flying hour} \times \text{monthly programmed flying hours}}{\text{Maintenance hours available per man per month}}$$

EXAMPLE: Determine the number of direct maintenance personnel required to perform field maintenance on 20CH-34 (Choctaw) aircraft under the following conditions:

- 40 = monthly programmed flying hours
- 26 = workdays per month
- 12 = working hours per day
- 5.7 = man-hours per flying hour
- 24 = percent time off due to leave, KP, etc.
(leaves 76 percent available)

Direct maintenance personnel

$$= \frac{20 \times 5.7 \times 40}{12 \times 26 \times 0.76} = 20$$

2.27 Helicopter Planning Factors

a. Hours of Operation. Four hours per 24-hour day.

b. Operating Speed. Number of statute miles or kilometers traveled in 1 hour equals normal cruising speed less 15 miles (24 kilometers) per hour. This allows for reduction in speed prior to landing and immediately after takeoff.

CHAPTER 3

MOTOR

Section I. ORGANIZATION

3.1 Organization

<i>Unit</i>	<i>TOE</i>	<i>Mission and/or capability</i>	<i>Assignment</i>
Headquarters and headquarters company, transportation motor transport command.	55-11	To command, plan, supervise, coordinate, and control the activities of transportation highway transport groups and other assigned or attached units required in the movement of cargo or personnel by highway transport, particularly in a continuous intersectional or other linehaul operation.	To an army or to a theater army logistical command.
Headquarters and headquarters detachment, transportation truck group.	55-12	To command, plan, and control operations of transportation truck, amphibious truck, or tracked vehicle battalions.	To an army, COMMZ, or logistical command. May be attached to a highway transport command headquarters, but may operate separately under appropriate staff transportation officer.
Headquarters and headquarters detachment, transportation truck battalion.	55-16	To command and supervise units engaged in all types of motor transport, such as direct support of tactical units, port or beach clearance, depot and terminal operations, and linehauls.	To a field army or COMMZ. May be attached to a transportation truck group headquarters or a highway transport command headquarters, but may operate separately under appropriate transportation staff officer.
Transportation light truck company. ^a	55-17	To provide truck transportation for movement of personnel and general cargo, using either 2½-ton or 5-ton cargo trucks.	To logistical command or field army. Normally attached to a transportation truck battalion, but may operate separately under appropriate staff transportation officer.
Transportation medium truck company. ^a	55-18	To transport, by semitrailer of type required, general cargo, bulk petroleum products, refrigerated cargo, and missiles.	To a logistical command or field army. Normally attached to a transportation truck battalion, but may operate separately under appropriate staff transportation officer.
Transportation car company.	55-19	To transport personnel and light cargo by light motor vehicles.	To a transportation truck battalion, a theater headquarters, an army corps, airborne corps, or logistical command, but may operate separately under appropriate transportation officer.
Transportation cargo carrier company (tracked).	55-27	To transport personnel and cargo in tactical or logistical operations in arctic regions where conventional vehicles cannot be used.	To an infantry division, or field army, or logistical command for arctic operations.
Transportation heavy truck company. ^a	55-28	To transport heavy or bulky vehicles and/or outsized cargo.	To logistical command or field army. Normally attached to a transportation truck battalion, but may operate separately under appropriate staff transportation officer.

^a May be adapted to use non-U. S. personnel; see type B column of appropriate TOE.

<i>Unit</i>	<i>TOE</i>	<i>Mission and/or capability</i>	<i>Assignment</i>
Headquarters and headquarters detachment, transportation tactical carrier battalion.	55-46	To provide command and administration for transportation tactical carrier companies.	To a corps or field army (normally 2 per corps).
Transportation tactical carrier company.	55-47	To provide protected tactical mobility and resupply, and to supplement Army medical service evacuation of casualties in direct support of combat elements of the infantry division or special task forces.	To a corps or field army, normally in a transportation tactical carrier battalion, but may operate separately under appropriate staff transportation officer.
<i>ROCID:</i>			
Infantry division, transportation battalion.	55-75 ^b	To provide tactical mobility to assault elements of an infantry division for pursuit, exploitation, and other tactical task-force type requirements.	Organic to infantry division, TOE 7 (ROCID).
Headquarters and headquarters company, infantry division, transportation battalion.	55-76	To provide command and administration for assigned units.	Organic to infantry division, transportation battalion TOE 55-75.
Truck transport company, infantry division, transportation battalion.	55-77	To provide transportation for the tactical and logistical movement of personnel and cargo of an infantry division.	Organic to infantry division, transportation battalion, TOE 55-75.
Armored carrier company, infantry division, transportation battalion.	55-78	To provide certain combat elements of the infantry division with protected tactical mobility. Capable of operating on roadways or cross-country.	Organic to infantry division, transportation battalion, TOE 55-75.
<i>ROAD:</i>			
Transportation motor transport company, armored or mechanized division supply and transport battalion.	55-87	To provide transportation for unit distribution of all classes of supply except class V.	Organic to armored or mechanized division supply and transport battalion (TOE 29-65).
Transportation motor transport company, infantry division supply and transport battalion.	55-88	To provide transportation for unit distribution of all classes of supply except class V.	Organic to infantry division supply and transport battalion (TOE 29-5).
Transportation motor transport company, airborne division supply and transport battalion.	55-97	To provide transportation for unit distribution of all classes of supply except class V.	Organic to airborne division supply and transport battalion (TOE 29-45).
Team GF, trailer transfer point, operating. ^c	50-500	To operate a trailer transfer point in conjunction with a linehaul operation (250 12-ton trailer units in-and-out per day).	To transportation highway transport command (1 per trailer transfer point in operation).
Team GG, highway regulation point.	55-500	To operate a highway regulation point on a 24-hour-per-day basis to avoid congestion and conflict of traffic.	To a logistical command or field army, with attachment to transportation truck group. Normally 1 team assigned for each 30 to 40 miles of road net along which highway regulation is maintained.

^b Recapitulation of TOE of subordinate units.

^c See TOE 55-500 for additional motor transport teams.

Section II. VEHICLES AND EQUIPMENT

3.2 Vehicle Characteristics

(May be assigned to U. S. or allied motor transport units)	Type ¹ (May be assigned to U. S. or allied motor transport units)	Combination ²	Vehicle class	Dimensions (in.)			Net weight (lb)	Pax and equip ³	Shipping dimensions (uncrated)			Fuel loaded (mpg)	Fuel tank cap. (gal.)	Cooling system cap. (qt) ⁴
				Length	Width	Height (max.)			Cu ft	Sq ft	MT			
Automobile, sedan, lt, Chev.....			2	197	74	66	3,220	4	550	100	13.7	14	16	16
Automobile, sedan, med, Buick.....			2	204	80	64	3,786	4	596	112	14.9	13	19	15
Bus, 37-pax, 4 × 2, M37RC.....			13	411	96	120	16,300	37	2,740	274	68.5	4	75	36
Carrier, cargo, amph, 1½T, T46E1.....			6	193	98	104	8,813	8	1,180	132	29.5	2.3	70	
Carrier, cargo, M29.....			3	126	61	71	4,077		337	57	8.4	5	35	13
Carrier, cargo, amph, M29C.....			3	193	68	71	4,778		524	90	13.1	5	35	13
Carrier, cargo, amph, M76.....			6	188	98	108	11,000		1,139	132	28.5	2.3	70	
Carrier, pers, full-tracked, armd, M59.....			19	221	129	94	39,504	11	1,520	186	38.1	1	136	56
Carrier, pers, full-tracked, armd, M75.....			20	205	120	120	36,669	11	1,438	159	36	0.8	150	
Carrier, pers, full-tracked, armd, M113 (T113E2).....			9	192	106	99	19,755	12	1,025	141	25.6	2.5	80	38
Dolly, tlr converter, 6T, 2W, M197A1.....				108	93	52	2,970		306	73	7.7			
Dolly, tlr converter, 8T, 2W, M198A1.....			2	115	97	56	3,500		351	81	8.8			
Dolly, tlr converter, 18T, 4W, M119.....			4		115	59	7,700		579	120	14.5			
Landing vehicle, tracked, Mk 4, LVT(4).....			16	314	128	99	27,400		2,290	279	57.4	0.9	140	
Station wagon, 8-pax, M2119.....			2	198	74	70	3,580	8	593	102	14.8	12	16	16
Stlr, cargo, stake, 6T, 2W, M118A1.....		7	11	276	93	133	7,140		1,534	180	38.4			
Stlr, cargo, van, 6T, 2W, M119A1.....		7	10	275	93	104	7,180		2,076	184	51.8			
Stlr, tanker, 6T, 2W, M30.....		9	9	240	96	93	6,750		1,790	161	44.7			
Stlr, refrig, van, 7½T, 2W, M349A1.....		7, 9	10	284	97	130	7,000		1,668	169	41.8			
Stlr, cargo, stake, 10T, 2W, SKD2361.....		9	14	307	96	108	9,430		1,785	204	44.7			
Stlr, low-bed, wrecker, 12T, 4W, M269A1.....		9	22	410	97	121	14,200		1,316	275	45.4			
Stlr, low-bed, wrecker, 12T, 4W, M270A1.....		9	24	591	97	121	17,500		2,612	393	65.3			
Stlr, cargo, stake, 12T, 4W, M127A1.....		9	25	344	97	109	13,500		2,070	230	51.8			
Stlr, tanker, gasoline, 12T, 4W, M131.....		9	21	361	96	111	14,850		2,121	237	53.1			
Stlr, tanker, gasoline, 12T, 4W, M131A1 & M131A1C.....		9	21	352	97	114	14,280		2,236	236	55.9			
Stlr, tanker, gasoline, 12T, 4W, M131A2.....		9	21	389	97	114	12,400		2,250	252	56.3			
Stlr, cargo, van, 12T, 4W, M128A1.....		9	21	350	97	143	14,695		1,807	236	45.2			
Stlr, low-bed, 15T, 4W, M172.....		9		404	116	64	15,500		1,719	322	43			
Stlr, tank transporter, 45T, 8W, M15A1.....		14, 15	59	462	150	105	42,370		3,490	398	87.5			
Stlr, tank transporter, 50T, 8W, M15A2.....		14, 15	78	462	150	105	42,600		3,490	398	87.5			
Tlr, cargo, amph, 2W, M100, ¼T.....		1		109	57	42	565		156	44	3.9			
Tlr, cargo, ¾T, 2W, M101.....		2		147	74	83	1,340		520	74	13			
Tlr, cargo, 1T, 2W, T6.....		2		146	72	73	1,300		437	72	11			
Tlr, cargo, 1½T, 2W, M104A1.....		3, 4, 5, 6, 8	6	166	83	100	2,730		446	96	11.1			
Tlr, cargo, 1½T, 2W, M105A2.....		3, 4, 5, 6, 8	6	160	83	96	2,650		430	96	10.8			
Tlr, tank, water, 400 gal., 1½T, 2W, M106A1.....		3, 4, 5, 6, 8	4	167	93	80	2,360		700	105	17.5			
Tlr, tank, water, 400 gal., 1½T, 2W, M107A2.....		3, 4, 5, 6, 8	4	160	83	77	2,289		597	94	14.9			
Tlr, flat-bed, guided missile, M261A1.....		3, 4, 5, 6, 8	6	308	95	47	7,694		1,888	307	47.2			

Trk, flat-bed, 10T, 4W, M345	10, 11	330	76	55	11,260	1,065	225	26.6				
Trk, util, ¼T, 4 × 4, lt, M422	1	107	61	60	1,700	3	224	46	5.6	19.2	13	
Trk, util, ¼T, 4 × 4, M151	1	132	63	71	2,140	3	248	57	6.2	17.3	17	8
Trk, util, ¼T, 4 × 4, M38A1	1	139	61	73	2,690	3	267	59	6.7	20	17.4	11
Trk, pickup, Chev, ½T, 4 × 2, M3104		197	75	76	3,330	1	650	103	16.2	11	17.5	14
Trk, ambulance, ¾T, 4 × 4, M43	4	199	74	92	7,150	4	790	103	19.8	9	24	17
Trk, cargo, ¾T, 4 × 4, M37B1	2	190	74	90	5,917	9	497	95	12.4	9	24	17
Trk, pickup, 1T, 4 × 4, M4-73-4WD	2	184	75	75	3,240	1	591	96	14.8	17	15	12
Trk, cargo, stake, 1½T, 4 × 2, Chev, M4409	8	265	88	88	5,675	2	1,181	161	29.5	8	17.5	16
Trk, cargo, 1½T, 4 × 4, G7127	3	296	86	106	8,150	20	1,282	177	32	6	30	17.5
Trk, cargo, LWB, 2½T, M35	4	11	262	96	111	12,465	20	1,610	174	40.2	5	50
Trk, cargo, stake, 2½T, M-K7	4	9	316	96	89	8,337	1	1,552	210	38.8	9	31
Trk, cargo, SWB, 2½T, 6 × 6, CCKW352	4	11	245	88	93	10,350	16	1,136	147	28.5	5	40
Trk, cargo, LWB, w/w, 6 × 6, M35	4	11	275	96	111	12,880	20	1,718	183	43.0	5	50
Trk, cargo, wo/w, 2½T, 6 × 6, M135	4	11	267	88	105	12,330	20	1,425	163	35.7	4	56
Trk, cargo, 2½T, 6 × 6, M34	4	11	262	88	105	11,775	20	1,094	160	27.4	6	50
Trk, cargo, 2½T, 6 × 6, M36C	4	11	323	96	125	13,500	28	2,240	217	56	6	50
Trk, cargo, 2½T, 6 × 6, M211	4	11	270	96	112	13,170	20	1,167	180	29.1	5.8	56
Trk, cargo, dump, 2½T, 6 × 6, M342	4	11			15,165	17	1,487		37.2	6	50	22
Trk, dump, 2½T, 6 × 6, M59	5	11	236	96	103	14,050		1,198	153	30	6	50
Trk, dump, 2½T, 6 × 6, M215	5	11	241	96	108	14,460		1,050	160	26.3	5.4	56
Trk, tank, water, 1,000 gal., 2½T, 6 × 6, M50	6	11	262	95	97	15,038	1	1,272	170	31.8	7	50
Trk, tank, gasoline, 1,200 gal., 2½T, 6 × 6, M217C	6	10	267	96	102	14,805	1	1,335	178	33.4	5.4	56
Trk, tank, gasoline, 1,200 gal., 2½T, 6 × 6, M49C	6	10	262	96	98	13,955	1	1,260	173	31.5	7	50
Trk, tank, water, 1,000 gal., 2½T, 6 × 6, M222	6	10	267	96	102	14,100	1	1,335	178	33.4	5.4	56
Trk, tank, water, 2½T, 6 × 6, CCKW353	6	8	254	90	95	11,913	1	1,260	159	31.5	5	40
Trk, tractor, 2½T, 6 × 6, M48	7	6	254	94	98	11,430	1	1,058	155	26.4	6	50
Trk, tractor, 2½T, 6 × 6, M221	7	5	233	96	103	11,695	1	1,015	155	25.4	5.8	56
Trk, tractor, 2½T, 6 × 6, M275	7	5	228	94	98	11,179	1	1,005	152	25.1	7	50
Trk, van, shop, 2½T, 6 × 6, CCKW353	8	7	256	96	118	10,100	1	1,690	171	42.4	5	40
Trk, van, shop, 2½T, 6 × 6, M109	8	11	262	96	129	15,231	1	1,822	174	45.5	7	50
Trk, van, shop, 2½T, 6 × 6, M220	8	11	267	96	131	15,085	1	1,940	178	48.5	5.4	56
Trk, wrecker, crane, 2½T, 6 × 6, M108	8	12	303	96	100	19,785	1	1,860	202	46.5	7	50
Trk, wrecker, lt, 2½T, 6 × 6, M60	8	13	303	96	101	23,960	1	1,696	202	42.5	6	50
Trk, tractor, 4-5T, 4 × 4, M444T	9	10	204	95	113	11,660	1	1,260	135	31.4	3	60
Trk, tractor, 5T, 4 × 2, M426	9	6	200	98	107	12,100	1	1,182	136	29.6	3	80
Trk, tractor, 5T, 6 × 6, M52	9	11	258	97	102	18,813	1	1,245	174	31.2	4.4	110
Trk, tractor-wrecker, LWB, w/w, 5T, 6 × 6, M246	9	25	353	100	132	32,830	1	2,626	238	65.9	4.4	78
Trk, wrecker, med, 5T, 6 × 6, M62	10	24	310	97	103	33,675	1	2,486	234	62	2.7	78
Trk, cargo, 5T, 6 × 6, M41	10	17	310	96	112	19,119	1	1,817	196	45.4	4.4	78
Trk, cargo, 5T, 6 × 6, M54	10	14	299	97	116	19,230	22	1,945	201	58.7	2.7	78
Trk, cargo, LWB, 5T, 6 × 6, w/w, M54	10	14	310	97	116	19,945	22	2,046	211	51.2	2.7	78
Trk, cargo, 5T, 6 × 6, M55	10	21	371	97	118	24,064	30	2,544	259	63.6	2.7	78
Trk, dump, 5T, 6 × 6, M51	11	20	267	97	111	21,981	1	1,318	179	33.0	4.4	110
Trk, wrecker, 6T, 6 × 6, M1A1	11	20	348	100	117	30,000	1	1,900	195	47.5	2	100
Trk, cargo, 10T, 6 × 6, M125	12	33	332	114	112	31,600	22	1,902	252	47.5	3	110

Type ¹ (May be assigned to U. S. or allied motor transport units)	Combination ²	Vehicle class	Dimensions (in.)			Net weight (lb)	Pax and equip ³	Shipping dimensions (uncrated)			Fuel loaded (mpg)	Fuel tank cap. (gal.)	Cooling system cap. (qt) ⁴
			Length	Width	Height (max.)			Cu ft	Sq ft	MT			
Trk, tractor, 10T, 6 × 6, M123C.....	13	18	280	114	113	32,250	1	2,070	221	51.8	1.8	166	64
Trk, tractor, 12T, 6 × 6, M26A2.....	14	28	306	131	123	48,895	-----	2,957	278	74	1	120	56
Trk, tractor, 15T, 8 × 8, M194.....	15	48	338	124	109	45,000	-----	2,500	291	62.5			

¹ Some vehicle types shown are no longer standard items of issue for U. S. forces. They are included because these types are still found in motor transport units of the armed forces of some allied nations.

² Trailers and semitrailers will form combinations with trucks having the same number.

³ Does not include crew.

⁴ See paragraph 7.11 for antifreeze applications.

Type ¹ (May be assigned to U. S. or allied motor transport units)	POL for 100 miles (161 km) (loaded)				Towed loads (lb)		Payloads (lb)		Cargo carrying dimensions (in.)			Loading height (in.)	Cruising range (loaded)	
	Fuel (gal.)	Oil (gal.)	Lube (lb)	Grease (lb)	Hwy opns	Inferior roads	Hwy opns	Inferior roads	Length	Width	Height		Miles	Kilo-meters
Automobile, sedan, lt, Chev.....	7.2	0.2	0.1	0.1			800						224	361
Automobile, sedan, med, Buick.....	7.7	0.2	0.1	0.1			750						247	397
Bus, 37-pax, 4 × 2, M37RC.....	25.0	0.6	0.3	0.4			8,700						300	483
Carrier, cargo, amph, 1½T, T46E1.....	43.4	2.8	1.9	0.9	6,000	6,000	3,000	3,000	91	68	58		161	259
Carrier, cargo, M29.....	20.0	1.4	0.9	0.5	3,800	3,800	1,200	1,200					175	282
Carrier, cargo, amph, M29C.....	20.0	1.4	0.9	0.5	3,800	3,800	1,200	1,200					175	282
Carrier, cargo, amph, M76.....	43.4	1.6	1.0	1.6	6,000	6,000	1,160	1,160					161	259
Carrier, pers, full-tracked, armd, M59.....	100.0	2.0	2.5	2.0	14,000	14,000	3,100	3,100					136	218
Carrier, pers, full-tracked, armd, M75.....	125.0	2.0	2.5	2.0	14,000	14,000	5,300	5,300					120	193
Carrier, pers, full-tracked, armd, M113 (T113E2).....	40.0	1.8	2.0	1.8	24,000	24,000	3,860	3,860					200	322
Dolly, tlr converter, 6T, 2W, M197A1.....				0.1			12,000					52		
Dolly, tlr converter, 8T, 2W, M198A1.....				0.1			16,000					56		
Dolly, tlr, converter, 18T, 4W, M119.....				0.1			36,000					59		
Landing vehicle, tracked, Mk 4, LVT(4).....	111.0				30,000	30,000	9,000	9,000					126	203
Station wagon, 8-pax, M2119.....	8.3	0.2	0.1	0.1			1,400						192	309
Stlr, cargo, stake, 6T, 2W, M118A1.....							16,200	12,000	266	88	48	48		
Stlr, cargo, van, 6T, 2W, M119A1.....							16,200	12,000	266	87	55	47		
Stlr, tanker, 6T, 2W, M30.....							12,200							
Stlr, refrig, van, 7½T, 2W, M349A1.....							15,000		244	85	56	50		
Stlr, cargo, stake, 10T, 2W, SKD2361.....							22,000	20,000	300	87	48	53		
Stlr, low-bed, wrecker, 12T, 4W, M269A1.....							40,000	24,000	300	96		49		
Stlr, low-bed, wrecker, 12T, 4W, M270A1.....							40,000	24,000	480	96		49		
Stlr, cargo, stake, 12T, 4W, M127A1.....							36,000	24,000	335	88	48	61		
Stlr, tanker, gasoline, 12T, 4W, M131.....							30,540	19,620				109		
Stlr, tanker, gasoline, 12T, 4W, M131A1, M131A1C.....							30,500	19,645				109		
Stlr, tanker, gasoline, 12T, 4W, M131A2.....							30,500	20,344				109		
Stlr, cargo, van, 12T, 4W, M128A1.....							36,000	24,000				49		
Stlr, low-bed, 15T, 4W, M172.....							30,000		248	115		35		

Stlr, tank transporter, 45T, 8W, M15A1							90,000		292	131		41		
Stlr, tank transporter, 50T, 8W, M15A2							100,000		292	131		41		
Trl, cargo, amph, 1/4T, 2W, M100							750	500	72	38	18	42		
Trl, cargo, 3/4T, 2W, M101							2,250	1,500	96	66	50	35		
Trl, cargo, 1T, 2W, T6							3,000	2,000	96	46	44	31		
Trl, cargo, 1 1/2T, 2W, M104A1							5,500	3,000	110	74	60	36		
Trl, cargo, 1 1/2T, 2W, M105A2							4,500	3,000	110	74	60	35		
Trl, tank, water, 1 1/2T, 400 gal., 2W, M106A1							3,335	3,335			80			
Trl, tank, water, 400 gal., 1 1/2T, 2W, M107A2							3,335	3,335				77		
Trl, flat-bed, guided missile, M261A1							3,245	3,245	308	95		47		
Trl, flat-bed, 10T, 4W, M345							26,000	20,000	276	76		55		
Trk, util, 1/4T, 4 x 4, 1t, M422	5.2	0.2	0.2	0.2	1,500	1,000	1,000	850					250	402
Trk, util, 1/4T, 4 x 4, M151	5.8	0.2	0.2	0.2	2,000	1,500	1,200	800					294	473
Trk, util, 1/4T, 4 x 4, M38A1	5.0	0.2	0.2	0.2	2,000	1,500	1,200	800					350	563
Trk, pickup, 1/2T, 4 x 2, M3104	9.2	0.2	0.2	0.2	2,000	1,500	1,270		78	50	16	30	192	309
Trk, ambulance, 3/4T, 4 x 4, M43	11.1	0.2	0.3	0.3	3,000	1,000	1,400					34	216	348
Trk, cargo, 3/4T, 4 x 4, M37B1	11.1	0.2	0.3	0.3	6,000	4,000	2,000	1,500	78	64	55	30	216	348
Trk, pickup, 1T, 4 x 4, M4-73-4WD	5.9	0.2	0.3	0.3	3,000	2,000	2,060		78	48	13	28	255	410
Trk, cargo, stake, 2 1/2T, 4 x 4, Chev, M4409	12.5	0.2	0.3	0.3	5,000	2,000	6,825	3,000	141	80	38	49	140	225
Trk, cargo, 1 1/2T, 4 x 4, G7127	16.6	0.2	0.3	0.3	8,000		4,800	3,350	180	70	59	47	180	290
Trk, cargo, LWB, 2 1/2T, M35	20.0	0.4	0.8	0.4	10,000	6,000	10,000	5,000	147	88	60	51	250	402
Trk, cargo, stake, 2 1/2T, M-K7	11.1	0.4	0.3	0.4	6,000	3,000	7,000	5,000	192	90	42	46	279	449
Trk, cargo, SWB, 2 1/2T, 6 x 6, CCKW352	20.0	0.4	0.8	0.4	10,000	6,000	10,000	5,350	120	81	64	48	200	322
Trk, cargo, LWB, w/w, 2 1/2T, 6 x 6, M35	20.0	0.4	0.8	0.4	10,000	6,000	10,000	5,000	147	88	60	51	250	402
Trk, cargo, wo/w, 2 1/2T, 6 x 6, M135	25.0	0.4	1.6	0.4	10,000	6,000	10,000	5,000	147	80	60	45	224	360
Trk, cargo, 2 1/2T, 6 x 6, M34	16.7	0.4	0.8	0.4	10,000	6,000	10,000	5,000	147	80	60	44	300	483
Trk, cargo, 2 1/2T, 6 x 6, M36C	16.7	0.4	0.8	0.4	10,000	6,000	10,000	5,000	204	88	60	51	300	483
Trk, cargo, 2 1/2T, 6 x 6, M211	17.2	0.4	0.8	0.4	10,000	6,000	10,000	5,000	147	88	60	51	325	523
Trk, cargo, dump, 2 1/2T, 6 x 6, M342	16.7	0.4	0.8	0.4	10,000	6,000	10,000	5,000	132	70	13		300	483
Trk, dump, 2 1/2T, 6 x 6, M59	16.7	0.4	0.8	0.4	10,000	6,000	10,000	5,000	108	70	16	69	300	483
Trk, dump, 2 1/2T, 6 x 6, M215	18.5	0.4	0.8	0.4	10,000	6,000	9,000	3,750	108	70	16	50	303	487
Trk, tank, water, 1,000 gal., 2 1/2T, 6 x 6, M50	14.3	0.4	0.8	0.4	10,000	6,000	8,500	3,500				96	350	563
Trk, tank, gasoline, 1,200 gal., 2 1/2T, 6 x 6, M217C	18.5	0.4	0.8	0.4	10,000	6,000	8,000	5,000				89	303	487
Trk, tank, gasoline, 1,200 gal., 2 1/2T, 6 x 6, M49C	14.3	0.4	0.8	0.4	10,000	6,000	8,000	5,000				89	350	563
Trk, tank, water, 1,000 gal., 2 1/2T, 6 x 6, M222	18.5	0.4	0.8	0.4	10,000	6,000	8,500	3,500				89	303	487
Trk, tank, water, 2 1/2T, 6 x 6, CCKW353	20.0	0.4	0.8	0.4	10,000	6,000		5,350					200	322
Trk, tractor, 2 1/2T, 6 x 6, M48	16.7	0.4	0.8	0.4	36,000	17,000	12,000	7,000				52	300	483
Trk, tractor, 2 1/2T, 6 x 6, M221	17.2	0.4	0.8	0.4	36,000	17,000	12,000	7,000				52	325	523
Trk, tractor, 2 1/2T, 6 x 6, M275	14.3	0.4	0.8	0.4	36,000	17,000	12,000	7,000				51	350	563
Trk, van, shop, 2 1/2T, 6 x 6, CCKW353	20.0	0.4	0.8	0.4	10,000	6,000	9,200	5,350	144	81	64	48	200	322
Trk, van, shop, 2 1/2T, 6 x 6, M109	14.3	0.4	0.8	0.4	8,000	6,000	7,500	5,000				40	350	563
Trk, van, shop, 2 1/2T, 6 x 6, M220	18.5	0.4	0.8	0.4	8,000	6,000	7,500	5,000				51	303	487
Trk, wrecker, crane, 2 1/2T, 6 x 6, M108	14.3	0.5	0.8	0.5	9,500	5,500	3,500	1,500					350	563
Trk, wrecker, lt, 2 1/2T, 6 x 6, M60	16.7	0.5	0.8	0.5	10,000	6,000	3,500	1,500					300	483
Trk, tractor, 4-5T, 4 x 4, M444T	33.2	0.6	0.3	0.4	20,000	10,000	9,350						180	290
Trk, tractor, 5T, 4 x 2, M426	33.2	0.6	0.3	0.4	30,000	15,000	15,400	13,000					240	386

See footnotes on page 50.

Type ¹ (May be assigned to U. S. or allied motor transport units)	POL for 100 miles (161 km) (loaded)				Towed loads (lb)		Payloads (lb)		Cargo carrying dimensions (in.)			Loading height (in.)	Cruising range (loaded)	
	Fuel (gal.)	Oil (gal.)	Lube (lb)	Grease (lb)	Hwy opns	Inferior roads	Hwy opns	Inferior roads	Length	Width	Height		Miles	Kilo- meters
Trk, tractor, 5T, 6 × 6, M52	22.7	0.6	0.9	0.8	55,000	30,000	25,000	15,000	-----	-----	-----	-----	484	779
Trk, tractor-wrecker, LWB, w/w, 5T, 6 × 6, M246	22.7	0.8	0.4	0.5	46,000	37,500	16,000	12,000	-----	-----	-----	-----	343	552
Trk, wrecker, med, 5T, 6 × 6, M62	37.0	0.8	0.4	0.5	30,000	20,000	12,000	7,000	-----	-----	-----	-----	211	339
Trk, cargo, 5T, 6 × 6, M41	22.7	0.8	0.4	0.5	30,000	15,000	15,000	10,000	168	88	60	55	343	552
Trk, cargo, 5T, 6 × 6, M54	37.0	0.8	0.4	0.5	30,000	15,000	20,350	10,350	168	88	60	55	211	339
Trk, cargo, LWB, 5T, 6 × 6, w/w, M54	37.0	0.9	0.4	0.5	30,000	15,000	20,350	10,350	168	88	60	55	211	339
Trk, cargo, 5T, 6 × 6, M55	37.0	0.9	0.5	0.6	30,000	15,000	20,000	10,000	244	88	60	57	211	339
Trk, dump, 5T, 6 × 6, M51	22.7	0.8	0.4	0.5	30,000	15,000	20,000	10,000	125	82	23	58	484	779
Trk, wrecker, 6T, 6 × 6, M1A1	50.0	0.8	0.4	0.5	60,000	40,000	8,000	-----	-----	-----	-----	-----	200	322
Trk, cargo, 10T, 6 × 6, M125	33.3	0.8	0.4	0.5	50,000	30,000	30,000	20,000	178	-----	-----	66	330	531
Trk, tractor, 10T, 6 × 6, M123C	55.0	1.5	0.9	1.1	135,000	80,000	35,000	30,000	-----	-----	-----	-----	300	483
Trk, tractor, 12T, 6 × 6, M26A2	100.0	1.5	0.9	1.1	117,500	-----	60,000	-----	-----	-----	-----	-----	120	193
Trk, tractor, 15T, 8 × 8, M194	-----	1.7	1.1	1.3	150,000	-----	51,000	-----	-----	-----	-----	-----	-----	-----

Type ¹ (May be assigned to U. S. or allied motor transport units)	Cargo space (cu ft)	Ideal stowage factor ³		Fordability (in.) ⁵		Max. grade- ability (%) ⁷	Tires				Max. recommended speed ⁶	
		Hwy opns	Inferior roads	w/kit	wo/kit		Number on ground	Max pressure (psi)	Ply	Size	Miles per hour	Kilometers per hour
Automobile, sedan, lt, Chev	-----	-----	-----	-----	15	35	4	24	4	6.70 × 15	70	112
Automobile, sedan, med, Buick	-----	-----	-----	-----	15	48	4	24	4	7.60 × 15	70	112
Bus, 37-pax, 4 × 2, M37RC	-----	-----	-----	-----	20	20	6	-----	12	10.00 × 20	60	96
Carrier, cargo, amph, 1½T, T46E1 ⁸	209	156	156	floats	-----	60	-----	-----	-----	-----	28	45
Carrier, cargo, M29 ⁸	-----	-----	-----	floats	-----	65	-----	-----	-----	-----	34	54
Carrier, cargo, amph, M29C ⁸	-----	-----	-----	floats	-----	65	-----	-----	-----	-----	36	57
Carrier, cargo, amph, M76 ⁸	-----	-----	-----	floats	-----	60	-----	-----	-----	-----	28	45
Carrier, pers, full-tracked, armd, M59 ⁸	-----	-----	-----	floats	-----	60	-----	-----	-----	-----	32	51
Carrier, pers, full-tracked, armd, M75 ⁸	-----	-----	-----	80 48	-----	60	-----	-----	-----	-----	44	70
Carrier, pers, full-tracked, armd, M113 (T113E2) ⁸	-----	-----	-----	floats	-----	60	-----	-----	-----	-----	40	64
Dolly, tlr converter, 6T, 2W, M197A1	-----	-----	-----	-----	-----	-----	4	40	8	9.00 × 20	-----	-----
Dolly, tlr converter, 8T, 2W, M198A1	-----	-----	-----	-----	-----	-----	4	50	10	11.00 × 20	-----	-----
Dolly, tlr converter, 18T, 4W, M119	-----	-----	-----	-----	-----	-----	8	85	12	14.00 × 20	-----	-----
Landing vehicle, tracked, Mk 4, LVT(4) ⁸	-----	-----	-----	floats	-----	60	-----	-----	-----	-----	15	24
Station wagon, 8-pax, M2119	-----	-----	-----	-----	13	30	4	30	6	6.70 × 15	65	104
Stlr, cargo, stake, 6T, 2W, M118A1	649	90	121	-----	-----	-----	4	40	8	9.00 × 20	-----	-----
Stlr, cargo, van, 6T, 2W, M119A1	736	102	137	-----	-----	-----	4	40	8	9.00 × 20	-----	-----
Stlr, tanker, 6T, 2W, M30	-----	-----	-----	-----	-----	-----	4	65	12	9.00 × 20	-----	-----
Stlr, refrig, van, 7½T, 2W, M349A1	671	100	-----	-----	-----	-----	4	40	8	9.00 × 20	-----	-----
Stlr, cargo, stake, 10T, 2W, SKD2361	726	74	81	-----	-----	-----	4	80	14	11.00 × 20	-----	-----
Stlr, low-bed, wrecker, 12T, 4W, M269A1	-----	-----	-----	-----	-----	-----	8	70	12	11.00 × 20	-----	-----

Stlr, low-bed, wrecker, 12T, 4W, M270A1							8	70	12	11.00 × 12		
Stlr, cargo, stake, 12T, 4W, M127A1	818	51	76				8	50	12	11.00 × 20		
Stlr, tanker, gasoline, 12T, 4W, M131						56	8	50	12	11.00 × 20		
Stlr, tanker, gasoline, 12T, 4W, M131A1& M131A1C						56	8	50	12	11.00 × 20		
Stlr, tanker, gasoline, 12T, 4W, M131A2						24	8	50	12	11.00 × 20		
Stlr, cargo, van, 12T, 4W, M128A1						55	8	50	12	11.00 × 20		
Stlr, low-bed, 15T, 4W, M172						36	8	85	14	10.00 × 15		
Stlr, tank, transporter, 45T, 8W, M15A1							8	90	20	14.00 × 24		
Stlr, tank transporter, 50T, 8W, M15A2							8	90	20	14.00 × 24		
Tlr, cargo, amph, ¼T, 2W, M100	28	84	126	floats			2	35	6	7.00 × 16		
Tlr, cargo, ¾T, 2W, M101	183	182	273				2	40	8	9.00 × 16		
Tlr, cargo, 1T, 2W, T6	112	84	125				2	55	8	7.50 × 20		
Tlr, cargo, 1½T, 2W, M104A1	282	115	210				2	50	12	11.00 × 20		
Tlr, cargo, 1½T, 2W, M105A2	282	141	210				2	45	8	9.00 × 20		
Tlr, tank, water, 400 gal., 1½T, 2W, M106A1							2	50	12	11.00 × 20		
Tlr, tank, water, 400 gal., 1½T, 2W, M107A2							2	45	8	9.00 × 20		
Tlr, flat-bed, guided missile, M261A1							8	34	8	9.00 × 16		
Tlr, flat-bed, 10T, 4W, M345							8	50	12	11.00 × 20		
Trk, util, ¼T, 4 × 4, lt, M422				60	21	60	4	25	4	6.00 × 16	62	99
Trk, util, ¼T, 4 × 4, M151					20	65	4	25	6	7.10 × 15	66	106
Trk, util, ¼T, 4 × 4, M38A1				79		69	4	28	6	7.00 × 16	55	88
Trk, pickup, Chev, ½T, 4 × 2, M3104	36	64			18	31	4	36	6	6.50 × 16	60	96
Trk, ambulance, ¾T, 4 × 4, M43						68	4	40	8	9.00 × 16	55	88
Trk, cargo, ¾T, 4 × 4, M37B1	159	178	238	84	42	65	4	40	8	9.00 × 16	55	88
Trk, pickup, 1T, 4 × 4, M4-73-4WD	28	31			18	41	4	45	6	7.00 × 16	60	96
Trk, cargo, stake, 1½T, 4 × 2, Chev, M4409	248	81	185		22	37	6	60	8	7.50 × 20	54	86
Trk, cargo, 1½T, 4 × 4, G7127	431	201	288		29	65	6	55	8	7.50 × 20	48	77
Trk, cargo, LWB, 2½T, M35	441	101	201	72		64	10	45	8	9.00 × 20	58	93
Trk, cargo, stake, 2½T, M-K7	420	135	188		26	39	6	60	10	8.25 × 20	45	772
Trk, cargo, SWB, 2½T, 6 × 6, CCKW352	360	81	151		30	65	10	55	8	7.50 × 20	45	72
Trk, cargo, LWB, w/w, 2½T, 6 × 6, M35	449	101	201	72		64	10	45	8	9.00 × 20	58	93
Trk, cargo, wo/w, 2½T, 6 × 6, M135	408	91	183		30	60	6	70	12	11.00 × 20	58	93
Trk, cargo, 2½T, 6 × 6, M34	408	91	183	72		64	6	50	12	11.00 × 20	58	93
Trk, cargo, 2½T, 6 × 6, M36C	623	140	280	72		64	10	45	8	9.00 × 20	58	93
Trk, cargo, 2½T, 6 × 6, M211	449	101	201		30	60	10	45	8	9.00 × 20	55	88
Trk, cargo, dump, 2½T, 6 × 6, M342	70	157	314	72	40	64	10	45	8	9.00 × 20	58	93
Trk, dump, 2½T, 6 × 6, M59	70	16	31	72	40	63	10	45	8	9.00 × 20	62	99
Trk, dump, 2½T, 6 × 6, M215	70	17	42	80	30	66	10	45	8	9.00 × 20	55	88
Trk, tank, water, 1,000 gal., 2½T, 6 × 6, M50				72	40	57	10	45	8	9.00 × 20	58	93
Trk, tank, gasoline, 1,200 gal., 2½T, 6 × 6, M217C				80	30	67	10	45	8	9.00 × 20	55	88
Trk, tank, gasoline, 1,200 gal., 2½T, 6 × 6, M49C				72	40	62	10	45	8	9.00 × 20	58	93
Trk, tank, water, 1,000 gal., 2½T, 6 × 6, M222				80	30	66	10	45	8	9.00 × 20	55	88
Trk, tank, water, 2½T, 6 × 6, CCKW353					30	65	10	55	8	7.50 × 20	45	72
Trk, tractor, 2½T, 6 × 6, M48					30	40	10	45	8	9.00 × 20	58	93
Trk, tractor, 2½T, 6 × 6, M221					30	52	10	45	8	9.00 × 20	55	88
Trk, tractor, 2½T, 6 × 6, M275					30	57	10	45	8	9.00 × 20	58	93

See footnotes on page 50.

Type ¹ (May be assigned to U. S. or allied motor transport units)	Cargo space (cu ft)	Ideal stowage factor ²		Fordability (in.) ³		Max. grade- ability (%) ²	Tires				Max. recommended speed ⁴	
		Hwy opns	Inferior roads	w/kit	wo/kit		Number on ground	Max pressure (psi)	Ply	Size	Miles per hour	Kilometers per hour
Trk, van, shop, 2½T, 6 × 6, CCKW353-----	432	105	181	-----	30	65	10	55	8	7.50 × 20	45	72
Trk, van, shop, 2½T, 6 × 6, M109-----	-----	-----	-----	72	40	57	10	45	8	9.00 × 20	58	93
Trk, van, shop, 2½T, 6 × 6, M220-----	-----	-----	-----	80	30	66	10	45	8	9.00 × 20	55	88
Trk, wrecker, crane, 2½T, 6 × 6, M108-----	-----	-----	-----	72	40	63	10	45	8	9.00 × 20	62	99
Trk, wrecker, lt, 2½T, 6 × 6, M60-----	-----	-----	-----	72	40	63	10	45	8	9.00 × 20	60	96
Trk, tractor, 4-5T, 4 × 4, M444T-----	-----	-----	-----	-----	24	52	6	65	10	9.00 × 20	41	66
Trk, tractor, 5T, 4 × 2, M426-----	-----	-----	-----	-----	35	25	6	70	14	11.00 × 20	38	61
Trk, tractor, 5T, 6 × 6, M52-----	-----	-----	-----	-----	30	77	10	70	12	11.00 × 20	52	83
Trk, tractor-wrecker, LWB, w/w, 5T, 6 × 6, M246-----	-----	-----	-----	-----	30	47	10	70	12	11.00 × 20	52	83
Trk, wrecker, med, 5T, 6 × 6, M62-----	-----	-----	-----	78	-----	36	10	70	12	11.00 × 20	52	83
Trk, cargo, 5T, 6 × 6, M41-----	513	77	115	-----	30	68	6	45	12	14.00 × 20	59	95
Trk, cargo, 5T, 6 × 6, M54-----	513	57	111	78	30	51	10	70	12	11.00 × 20	52	83
Trk, cargo, LWB, 5T, 6 × 6, w/w, M54-----	513	57	111	78	30	51	10	70	12	11.00 × 20	52	83
Trk, cargo, 5T, 6 × 6, M55-----	746	84	167	78	30	65	10	70	12	11.00 × 20	52	83
Trk, dump, 5T, 6 × 6, M51-----	137	15	30	78	30	70	10	70	12	11.00 × 20	52	83
Trk, wrecker, 6T, 6 × 6, M1A1-----	-----	-----	-----	-----	40	54	10	70	12	11.00 × 20	45	72
Trk, cargo, 10T, 6 × 6, M125-----	-----	-----	-----	78	30	60	10	90	20	14.00 × 24	42	67
Trk, tractor, 10T, 6 × 6, M123C-----	-----	-----	-----	-----	-----	60	10	90	20	14.00 × 24	42	67
Trk, tractor, 12T, 6 × 6, M26A2-----	-----	-----	-----	-----	56	30	10	90	20	14.00 × 24	28	45
Trk, tractor, 15T, 8 × 8, M194-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

¹ Cargo with higher stowage factor does not utilize all of vehicle weight-carrying capacity. Cargo with lower stowage factor does not utilize all of vehicle cubic capacity.

² Fordability and speed of trailers partly depend upon limitations of the prime mover (see column (2) for proper combinations). After fording, follow instructions contained in the vehicle technical manual.

³ Assuming good traction.

⁴ Ground pressure (psi): T46E1, 2.08; M29, 2.9; M29C, 1.91; M76, 2.1; M59, 7.1; M75, 8.2; M113, 7.3; LVT(4), 8.5.

(See page 46 for footnotes 1-4.)

3.3 Typical Truck Equipment for Motor Transport Units

a. *On-Equipment Material (OEM).* Equipment listed is typical but subject to change. For exact quantities the latest authorizations must be checked.

Items	¼ T	Truck ¾ T	2½ T	5 T
Bag, tool.....	1	1	1	1
Bracket, drum, flammable.....	1	1	1	1
Bracket, tool, pioneer equip.....	1	---	---	---
Chain, tow, ¼ in. × 16 ft.....	---	---	1*	---
Chain, tow, ½ in. × 16 ft.....	---	---	---	1
Handle, wheel stud nut.....	1	1	1	1
Hose, tire inflation.....	---	---	1	1
Jack, 1½-ton capacity.....	1	---	---	---
Jack, 3-ton capacity.....	---	1	1	---
Jack, 8-ton capacity.....	---	---	---	1
Pliers, comb, slip joint, 8 in.....	1	1	1	1
Screwdriver, common, hv duty, 4 in.....	1	---	---	---

Items	¼ T	Truck ¾ T	2½ T	5 T
Screwdriver, common, hv duty, 6 in.....	1	---	1	---
Screwdriver, common, hv duty, 9 in.....	---	---	---	1
Screwdriver, Phillips, No. 1.....	---	---	1	---
Screwdriver, Phillips, No. 2.....	---	---	1	---
Screwdriver, Phillips, No. 3.....	---	1	---	---
Wrench, adj, 8 in.....	1	1	1	1
Wrench, plug, straight bar.....	1	1	1	1
Wrench, wheel stud nut.....	1	1	1	1

* Issued on truck with winch.

b. *TOE Material.* The issue of this material varies with each type truck. It includes flashlight, MX-991 U; and goggles, M-1944.

c. *Special Material.*

Chains, tire, pair.....	As required by local weather conditions
Extinguisher, fire, 1-qt.....	As authorized by AR 385-55
Kit, deepwater fording.....	When authorized by theater of operations commander
Kit, winterization.....	

Section III. OPERATIONS

3.4 Outline of Standing Operating Procedure for Motor Transport Movements (Within Divisions Logistical Commands, or Higher Echelons)

a. *General.* Policies and factors involved in movements.

- (1) *Highway regulations.* Purpose, application or scope, responsibilities, methods and procedures for accomplishment.
- (2) *Convoy clearance.* Minimum vehicle requirements, convoy symbols, procedures, format for requesting and furnishing clearance, routing, halts, convoy composition, restrictions on tracked, overweight, or outsized vehicles.
- (3) *Highway regulation points.* Purpose, basis of establishment, responsibilities and procedures for operations, required records.
- (4) *Traffic control.* Responsibilities, relationship to highway regulation, coordination measures effected with provost marshal.
- (5) *Return loads.* Policies, methods, and procedures for securing and reporting.
- (6) *Convoy commanders.* Appointment, responsibilities, and functions; relationships with transportation personnel; instructions to be furnished.
- (7) *Halts.* Types, policies, procedures, and responsibilities for establishment and conduct of halts; area policing.
- (8) *Security.* Responsibilities and methods of conducting defensive measures.

(9) *Records and reports.* Responsibilities and methods for maintenance of required records, reference to reports to be submitted.

(10) *Communications.* Responsibilities and means of communication.

b. *Supply Movements.*

- (1) *Releases.* When required, methods of obtaining, formats, dissemination, actions required.
- (2) *Diversions and reconsignments.* Authority to effect diversions with consideration for various command areas, procedures for initiating requests, and execution.
- (3) *Records and reports.* Types of records required to be maintained on supply movements, reference to reports to be submitted.

3.5 Outline of Standing Operating Procedure for Motor Transport Service

a. *General.* Policies involved in control, operation, and maintenance of facilities, equipment, and installation; command responsibility; technical supervision required and agencies involved.

b. *Mission.* Service provided, extent of operation.

c. *Functions.*

- (1) Scheduled and nonscheduled operations.
- (2) Maintenance of equipment—responsibilities, procedures, facilities, and inspection practices.

d. *Operational Planning.* Computation of troop

and equipment requirements, capability estimate, communication procedure and requirements, rehabilitation requirements.

e. Operations. Operational procedures and controls, pooling and utilization of equipment.

f. Maintenance. Responsibilities and procedures for maintenance, regulations, and reports.

g. Supply Procedure. Responsibilities for supplies, authorized levels, requisitioning procedures, accounting methods, disposal of excesses.

h. Intelligence and Reconnaissance. Responsibility for collection, collation, evaluation, and dissemination of highway transportation intelligence and reconnaissance information.

i. Security. Responsibilities, plans—disaster and defense, convoy and cargo security, equipment and facilities.

j. Records and Reports. Responsibility, operational and personnel status reports, technical reports, miscellaneous.

k. Training. Responsibility—unit and technical training.

3.6 Vehicle Commitment Format

Routine commitment of vehicles requires the type of information outlined below. Those items not required for a particular unit should be eliminated. For nonroutine commitment and commitment of an entire unit for a substantial period of time, consideration should be given to the use of the five-paragraph operation order (FM 101-5).

a. Heading. The headquarters receiving the commitment, its location, and the date and hour of receipt.

b. Task (or Request).

- (1) Request number _____.
- (2) Received from (name & rank) (orgn) (phone).
- (3) To transport (tons) (type of cargo) (no. pers).
Cube _____ Peculiarities (shape, etc.).
From _____ To _____.
- (4) Recommended number and type of vehicles _____.
- (5) Terminal capabilities.
Origin _____ Est load time _____.
Destination _____ Est unload time _____.
- (6) Vehicles report to: (name, rank, title).
Location _____ Phone _____.
Time and date: Spot _____ Move _____.
- (7) On arrival at destination, report to:
(name, rank, title), location _____.
Phone _____.

c. Coordinating Instructions.

- (1) Type commitment:

One-time: _____ Recurring: _____.

If recurring, from _____ through _____.

- (2) Road information: (special routing, weather effects, limitations, etc.)

- (3) Shipment (has) (has not) been coordinated with consignor and consignee, regarding (refer to paragraph numbers above, or enter special information).

- (4) It (is) (is not) an emergency movement. If emergency, authorized by (name, rank, title, orgn) Phone _____.

- (5) Trailer pickup, movement, and delivery schedule.

(spot) (pickup) trailers at origin at (date-time)

Move trailer from _____ to _____.

By date-time _____.

Move trailer from _____ to _____.

By date-time _____.

Deliver trailers to destination for (unloading) (return loading) (return) at (date-time) _____.

d. Administrative and Logistical Matters.

- (1) Class III: (available origin) (available destination) (unit provide own).

- (2) Meals and billets: (available origin) (available destination) (not available).

- (3) Remarks: _____.

e. Command and Signal.

- (1) Reports required: _____.

- (2) Highway clearance requested (date-time), received (date-time), clearance number _____.

- (3) Special instructions: _____.

3.7 Traffic Circulation Plans

(fig. 3.1)

a. Traffic circulation plans (maps) are used to indicate a road net system of routes and to give necessary information and pertinent traffic restrictions.

b. The circulation plan establishes one-way, two-way, and alternating routes of traffic flow. Care must be taken to insure that routes are available for a circuitous flow in the required directions. A one-way route normally requires a compensating route in the opposite direction for the return of vehicles. Adequate access and egress routes must be provided along all routes. Where the balance between main routes and access-egress routes is not maintained, the capability of main routes may be limited to the capability of the access or egress facilities.

c. Circulation plans show such information as open, supervised, express, dispatch, and reserved routes; light lines; area boundaries; distance between important points; bridge and other weight limitations; restrictions on speed, density, etc.; and location of dumps, depots, traffic control posts, and regulation points. Road information shown on circulation plans applies throughout the length of road between points shown by the symbol "U."

d. Circulation plans frequently consist of a standard map and an overlay which together give the needed information. If the necessary information is too much to put on one overlay, separate overlays may be used to show different types of information. The sketch in figure 3.1 is one example of a traffic circulation plan. When making a traffic circulation plan, the planner or operator must be guided by what information is required by users of the plan.

3.8 Bivouac Defense, Truck Company

a. *Standard Pattern.* Company standing operating procedure gives a standard pattern that can be modified to suit the situation and terrain. This

SOP should contain the sound or visual signals communication plan. Upon arriving at the bivouac site, each platoon takes its predetermined position in the perimeter, without orders. Company headquarters and the maintenance section occupy the center as a reserve. Figures 3.2 and 3.3 show typical temporary bivouac areas for a light truck company. Figure 3.2 illustrates a situation where there is no guerrilla activity and emphasis is placed upon passive defense. Figure 3.3 depicts a situation in which a light truck company, organized primarily for ground defense to provide some dispersion for defense against air attack, has modified its area to fit the situation and terrain. In both situations, dispersion and camouflage serve as the primary defense against air attack.

b. *Conduct of Defense.* The unit commander places on the perimeter the minimum number of men required to maintain reasonable security. The number of men on the perimeter depends upon the probability of attack by regular troops or guerrillas, upon the terrain and weather—including visibility, and upon the number of men available. The unit commander keeps himself informed on

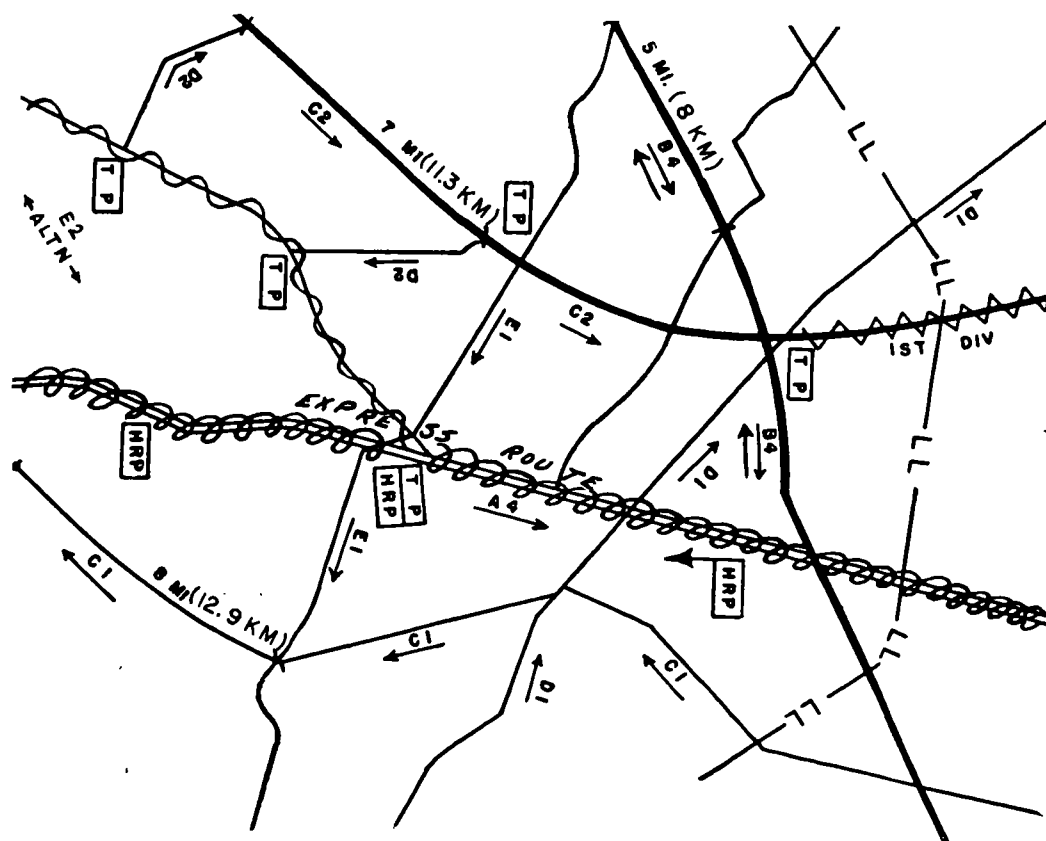


Figure 3.1. Traffic circulation plan.

the nearness and activity of enemy forces. He gains this information from his next higher headquarters, from the unit he is supporting or to which he is attached, and/or from friendly adjacent troops. When ground attack is imminent, men occupy the two-man foxholes. If required, one man stays alert while the other man sleeps. Each squad is given a sector. The squad leader and assistant squad leader occupy positions in rear of the squad. At all times the platoon leader and the squad leaders must know exactly where their men are and be prepared to alert them immediately.

c. *Trucks.* Trucks may be dispersed individually or in small groups, with about 100 yards (91 meters) between trucks or groups. Trucks are camouflaged and parked facing nearest exit road.

d. *Mines and Flares.* If available and authorized, a protective minefield consisting of fragmentation-type antipersonnel mines and trip flares is placed around the outer rim of the perimeter, about 200 yards (183 meters) in front of the foxholes and machine-gun emplacements (FM 20-32). One trailer in each platoon may carry numbered mines. These are placed in a standard sequence in every bivouac—mine No. 1 at 12 o'clock, then clockwise. The protective minefield can be installed quickly, and all mines can be located promptly and recovered when bivouac is cleared. Each minefield will be recorded and reported in accordance with the provisions of chapter 6, FM 20-32.

e. *Grenade and Rocket Launchers and Machine Guns.* Grenade and rocket launchers are used to

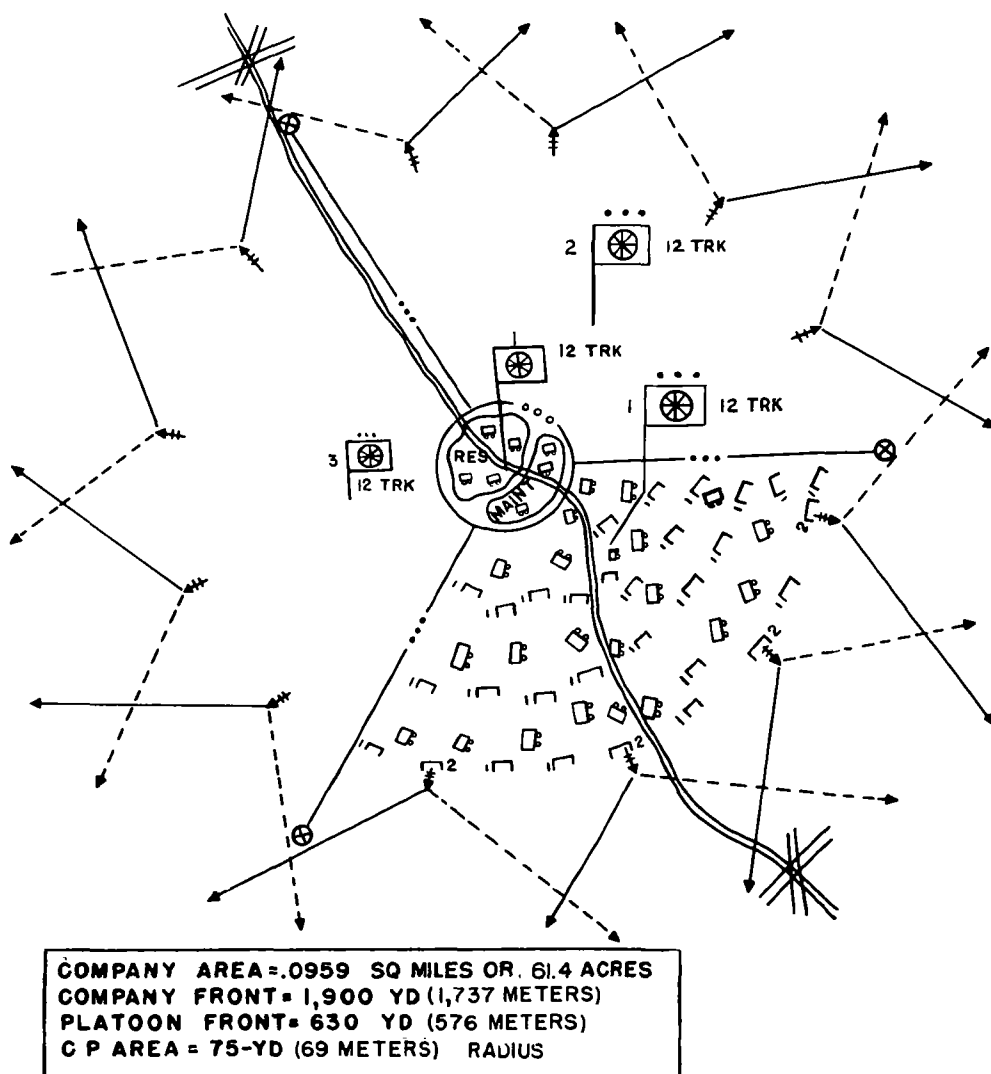


Figure 3.2. Schematic diagram, typical bivouac area, light truck company—passive defense emphasized.

protect areas most likely or suitable for enemy mechanized attack. Machine guns are placed to secure interlocking fires on the perimeter.

f. Passive Defense. The unit commander must continuously stress passive defense measures. All personnel should construct foxholes with adequate overhead cover immediately after occupying a bivouac area. Exposed personnel, even in rear areas, should be limited to the minimum number required to provide security and perform other necessary duties in the bivouac area.

3.9 Typical Truck Terminal

Figure 3.4 shows a typical truck terminal. Arrangement of facilities may deviate from the illustration, but the facilities indicated should be considered the minimum.

3.10 Reconnaissance

a. General. While some of the requirements outlined below may apply only to a particular reconnaissance, the entire list should be used to make sure no important factor is overlooked. In addition, when appropriate, the reconnaissance report should include special items such as weather conditions, information of value to other services, etc. For additional information, see FM 5-36.

b. Route Reconnaissance. This type of reconnaissance, which may be made from a map, is general in nature and is usually accompanied by a more detailed road reconnaissance (*c* below). The purpose of route reconnaissance is to gain information which will aid in the selection of a route or routes to be used for the movement of troops, troop equipment, and supplies in military operations.

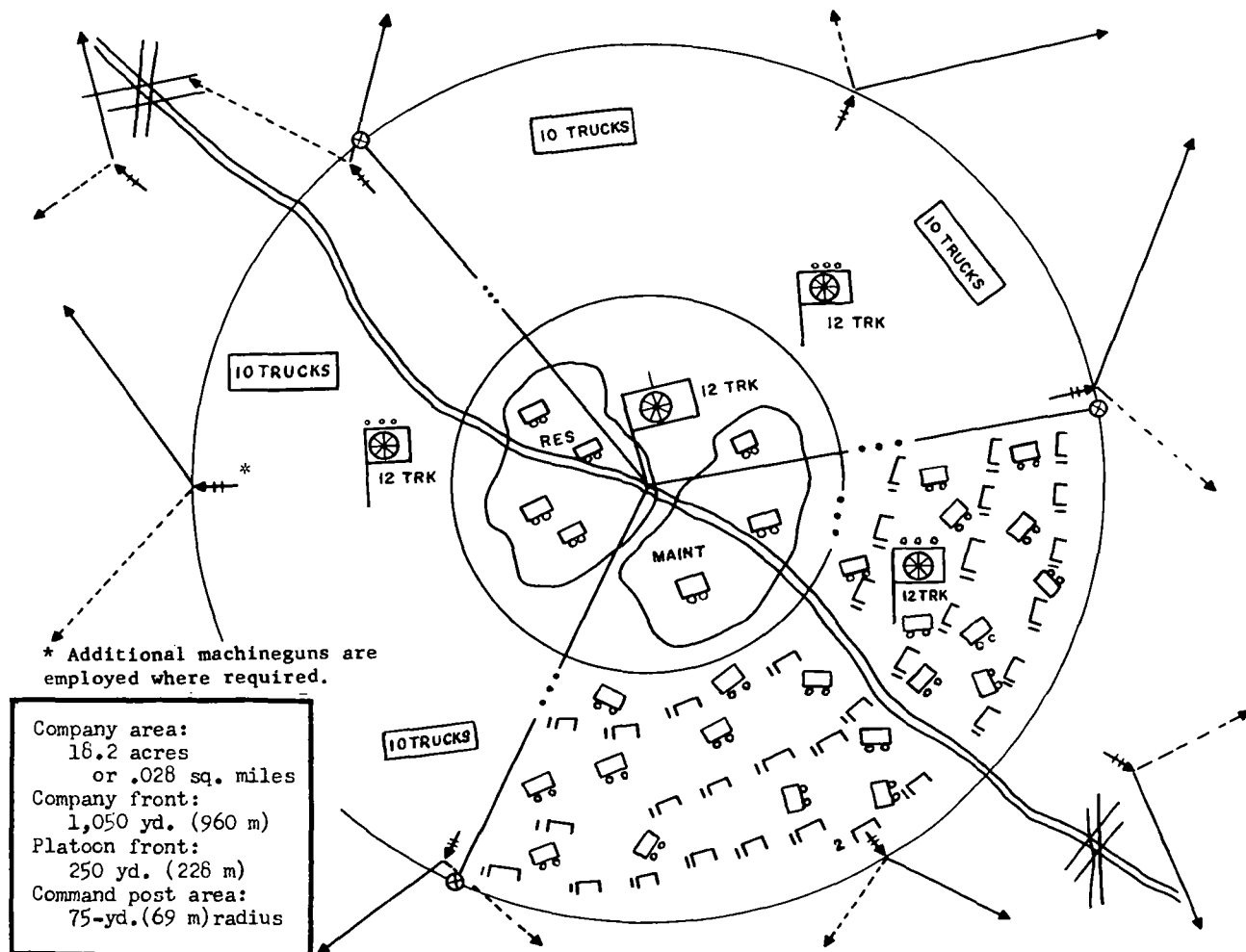


Figure 3.3. Schematic diagram, typical bivouac area, light truck company—organized primarily for ground defense.

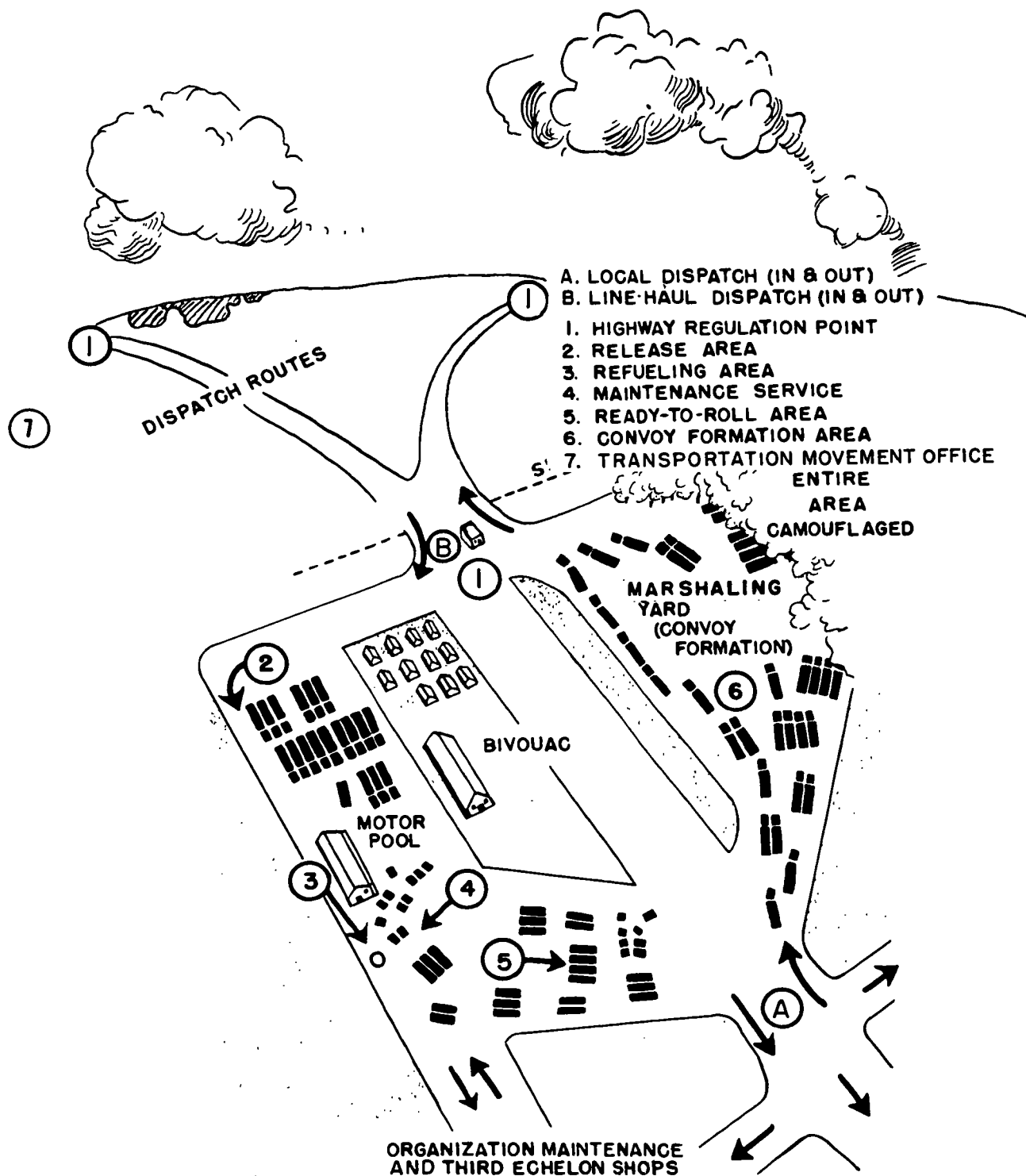


Figure 3.4. Typical truck terminal.

The route reconnaissance report includes the following information:

- (1) Date of reconnaissance; location and name, or number, of route.
- (2) Types of roads and distances between important points.
- (3) Type of terrain, including ruling grades of 7 percent or more.
- (4) Artificial obstacles, such as minefields, underpasses, narrow roads, narrow or low bridges, and tunnels, curves with radii less than 100 feet, etc.
- (5) Natural obstacles, such as swamps, mountains, streams, rivers, and obstacles peculiar to desert, jungle, and arctic areas.
- (6) Suitability and location of natural camouflage.
- (7) Effect of excessive snow and water and other weather extremes.
- (8) Alternate routes available.

c. Road Reconnaissance. Road reconnaissance is performed to obtain the information about existing roads upon which to base road classifications, primarily in support of the establishment of a route. It is concerned with the conditions of existing roads for immediate use and not for maintenance operations. The information obtained is used to estimate the quantity and kind of traffic and loads that a road can accommodate in its present condition. A road reconnaissance carried out by an officer or NCO other than an Engineer may require supplementation by an Engineer reconnaissance to provide additional data necessary for complete classification of the road. Although road reconnaissance should be made on the ground, it may be supplemented by aerial reconnaissance. Road reconnaissance reports are made on DA Forms 1248 through 1252, plus additional sheets as necessary, and are accompanied by appropriate data concerning bridges, tunnels, fords, ferries, obstructions, and bottlenecks. The following information is included:

- (1) *Roads.*
 - (a) Date and time of reconnaissance.
 - (b) Roadway name, number, and length.
 - (c) Type, including character of road surface, number and dimensions of useable lanes, width and condition of shoulders, location and degree of curves, and location and percent of grades.
 - (d) Type and condition of road base and subsoil.

- (e) Details of important junctions, access and egress roads, bypass routes, detours, railroad crossings, and railheads.
- (f) Details, including dates, of new construction or improvements planned or underway.
- (g) Location, type, condition, and restriction of communications facilities.
- (h) Condition of terrain, size, and drainage of adjacent areas, including halt, bivouac, and dump sites.
- (i) Distances (miles and kilometers) between all important points.
- (j) Location, length, and maximum interval between turnouts or passing places on one-way roads.
- (k) Obstructions, such as craters, roadblocks, mines, and destroyed culverts and bridges.
- (l) Defiles and possible bypasses.
- (m) Drainage provisions.
- (n) Visibility to enemy ground observers; vulnerability to nuclear weapons.
- (o) Traffic statistics, including monthly and annual traffic data by type of vehicle (car, truck, bus, etc.); location, time, and duration of peak loads; restrictions, including maximum permissible load; extent to which road is needed for civilian traffic.
- (p) Estimate of operating capacity of the road.

(2) *Bridges.*

- (a) Date and time of reconnaissance.
- (b) Name or number of bridge; location; load classification; length and width; clearance (vertical, side, and under bridge).
- (c) *Type of bridge.*
 1. *Floating.* Type of floating element (pneumatic float or boat), spacing between floating elements, means for fastening superstructure, curbs and handrails, roadway width, anchoring of bridge, dimensions, load capacity, maximum speed for crossing, vehicle spacing required, and type of traffic (foot or vehicular).
 2. *Fixed.* Characteristics of stringer, girder, suspension, truss, etc.
- (d) Number of spans, length, length of panels, anchoring methods.

- (e) Number of lanes and widths of each; separate walkway.
 - (f) Type of abutments, material, dimensions, type of soil.
 - (g) Location of dams, locks, and similar structures nearby.
 - (h) Depth of stream or river, width, current velocity, type of bottom and its bearing capacity, description of banks.
 - (i) Type of intermediate supports, material, number, location, spacing, sizes and placement of members.
 - (j) Charges or fares for toll bridges.
 - (k) Number of stringers per span, type, material, size, spacing.
 - (l) Safety and security features; bypass conditions.
 - (m) Type of flooring material, roadway clearance, thickness, number of layers (for plank floor), and thickness and direction of each layer.
 - (n) Description and condition of approaches.
 - (o) Physical condition of the structure and apparatus, including condition of welding, rivets, bolts; requirements for major repairs or improvements.
 - (p) Vulnerability to damage by flood or ice, including possible flanking of abutments by erosion.
 - (q) Drawbridges: type and dimensions; clearance width(s), allowing for fenders and for navigation of passageway; clearance height of lift spans when raised (specify stage of river); details of operating machinery; practicability of hand operation, including time required to open and close; time required to open and close by machinery; how frequently the span is normally opened; how frequently it would have to be opened to handle water traffic deemed essential under theater policies; availability of trained and trustworthy operators.
- (3) *Tunnels.*
- (a) Date and time of reconnaissance.
 - (b) Route name, number, and section.
 - (c) Tunnel name, number, or other identification.
 - (d) Coordinates and distance in miles or kilometers from an easily identified reference point.
 - (e) Nearest town identifiable on a map or photograph.
 - (f) Description and condition of approaches.
 - (g) Type of earth or rock through which tunnel passes.
 - (h) Type of roadway surface, condition, and traffic lanes.
 - (i) Truck traffic clearances, including useable roadway width, minimum vertical clearance, minimum radius of curvature, and maximum roadway gradient.
 - (j) Volume of traffic by type.
 - (k) Type and adequacy of drainage, lighting (power source), and ventilation (ventilating plant).
 - (l) Details of repair, storage, and parking facilities within tunnel or vicinity.
 - (m) Nature and condition of supporting walls, ceiling, lining, portals, and demolition chambers.
 - (n) Detours available and distances involved.
 - (o) Map, photographic, and basic document references, including design specifications and clearance or cross-sectional diagrams showing overall dimensions and minimum clearances for truck traffic.
 - (p) Vulnerability to nuclear weapons, including suitability as shelter from these weapons.
- (4) *Fords.*
- (a) Date and time of reconnaissance.
 - (b) Route name or number, name or number of ford, and locations.
 - (c) Alinement, gradient, and condition of banks and approaches.
 - (d) Length of ford or width of streambed.
 - (e) Type of roadway surface, useable width, traffic lanes, and condition.
 - (f) Depth of water and velocity of current at different seasons. (Good fords are less than 2 feet deep and have less than 3 miles per hour currents.)
 - (g) Limiting factors (load and speed restrictions, etc.), normal crossing time, and periods unuseable.
 - (h) Detours and alternate crossing sites, including evaluation of streambed above and below the ford.
 - (i) General suitability for foot, wheeled, and tracked crossing.

- (j) Map and photographic references, plans, charts, and diagrams.
- (5) *Ferries.*
 - (a) Date and time of reconnaissance.
 - (b) Location, identification, route name or number, name of terminals.
 - (c) Water distance between terminals.
 - (d) Water depths, velocity of current, tide data, and navigational aids and hazards.
 - (e) Description and condition of approaches.
 - (f) Possible alternate routes or crossing points.
 - (g) Name, age, and condition of ferries in service, including statement of capacities in short tons and in number of passengers and vehicles, by sizes.
 - (h) Technical details of ferry including length, beam, and draft; type of propulsion (poles, oars, pulleys, hand, winches, propellers, etc.); type of power (steam, gasoline, diesel, etc.) and horsepower; fuel capacity and source; method of unloading (side or end); deck dimensions.
 - (i) Number, type, and efficiency of operating personnel.
 - (j) Largest and heaviest vehicles or loads handled and techniques employed.
 - (k) Crossing time (light and loaded) and round-trip time, including loading, unloading, and docking time.
 - (l) Number of trips actually made per day.
 - (m) Effect of seasonal conditions (snow, ice, flood, etc.).
 - (n) Periods not operational and causes.
 - (o) Operating capacity and limiting factors of terminals, including handling, storage, fueling, repair, maintenance, loading or clearance facilities, equipment, and personnel.
 - (p) Type of landing (pier, wharf, beach, etc.).
 - (q) Potentialities for military transportation use.
- (6) *Additional information.* Including information of value to other services, special items, weather conditions at time of reconnaissance, etc.

3.11 Route and Road Classification

a. *Route Classification.* The general classifica-

tion of a route is designed to aid in planning motor transport movements. It includes the minimum width, type, and load capacity of roads and bridges on the route and indicates obstructions and weather effects.

- (1) *Types of routes.* For the purpose of classification, highway routes are classified X, Y, or Z as defined below.
 - (a) *Type X (all-weather).* This type of route has strong foundations and a waterproof surface of concrete, bituminous concrete, brick, or stone. With normal maintenance, it can be used all year by a volume of traffic which approximates its dry-weather capacity. The only weather effects which may cause the route to be closed are snow and flood.
 - (b) *Type Y (all-weather).* This type usually does not have a waterproof surface and is characterized by moderate foundations and surfaces of crushed rock, waterbound macadam, gravel, or bituminous-surface treatment. With normal maintenance, it can be used all year by a volume of traffic which is considerably less than its dry weather capacity. In addition to the effects of flood and snow, this route is also affected by rain, frost, or thaw. Heavy use during adverse weather conditions may lead to complete failure.
 - (c) *Type Z (fair-weather).* A route which quickly fails in bad weather and can only be kept open by major repairs and reconstruction. This type is so seriously affected by rain, frost, and thaw that traffic must be discontinued for long periods. It is characterized by weak foundations and surfaces of natural or stabilized soil, sand, clay, shell, cinders, or disintegrated granite.
- (2) *Method of classification.* The general classification of a route is usually made by the Corps of Engineers, which assesses the classification in accordance with information contained in road classification (b below). Routes are classified according to width, type, load capacity, obstructions, snow blockage, and flooding.
 - (a) *Width.* This is expressed in meters or

feet and refers to the width of the most narrow road on the route.

- (b) *Type*. Type refers to the worst type of road (X, Y, or Z) on the route.
 - (c) *Load capacity*. This refers to the maximum class of vehicle which can use the route in convoy; normally, this is the bridge classification of the weakest bridge on the route.
 - (d) *Obstructions*. The effect of a single or a temporary obstruction on a route should not be the limiting factor for classifying the route but should be noted in the formula for route classification by the symbol (Ob) and described completely in an accompanying report or on an overlay.
 - (e) *Snow blockage*. The effects of snow on military traffic depend upon snow clearance capability, which in turn depends upon such factors as the availability of machines and operators and the severity of the season. If snow blockage is regular, recurrent, and serious, the formula classifying the route is followed by (T).
 - (f) *Flooding*. If flooding is regular, recurrent, and serious, the formula classifying the route is followed by (W).
- (3) *Examples of route-classification formulas.*
- (a) *20 ft Y 50 (Ob)*. This describes an all-weather route without a waterproof surface which is useable all year for limited traffic only. The route has a minimum width of 20 feet, can accommodate vehicles up to class 50, and has an obstruction.
 - (b) *10.5 m X 70 (T)*. This describes an all-weather, first-class route which has a minimum width of 10.5 meters. It can accommodate vehicles up to class 70, but is subject to serious snow blockage.
 - (c) *7 ft Z 3 (W)*. This describes a poor route that requires good weather for any type of operation. It has a minimum width of 7 feet and can accommodate vehicles up to class 3, but is subject to serious flooding.

b. *Road Classification*. A detailed classification of a road is necessary when general route classification will not provide sufficient information for the planner or operator of motor-transport equipment.

Road classification is used for a specific operation and is in addition to the general classification of the route. Basic factors involved and examples of road-classification formulas are shown below.

(1) *Basic factors.*

- (a) *Limiting factors*. Limiting factors are curves, gradients, drainage, foundation, surface condition, and camber or superelevation as discussed below. Symbols used in classification formulas are shown in parentheses.

1. *Curves (c)*. Sharp curves with radii of less than 100 feet or 30 meters which cause some slowing of convoy traffic. (As discussed in *a* above, these are also reported as obstructions.)
2. *Gradients (g)*. Steep gradients of 7 percent and above which cause some slowing of convoy traffic. (These are also reported as obstructions.)
3. *Drainage (d)*. Poor drainage caused by inadequate ditches, crown, or culverts, etc.
4. *Foundation (f)*. Weak foundation caused by unstable, loose, or easily displaced material.
5. *Surface (s)*. A rough surface with bumps, ruts, or potholes which may reduce convoy speed.
6. *Camber or superelevation (j)*. Excessive camber or superelevation which falls away so sharply that heavy vehicles may skid or drag toward the roadside.

- (b) *Width*. The width of the road (travelled way) is expressed in feet or meters followed by a slash (/) and the combined width of the travelled way and shoulders. The shoulders of a road may be classified as unuseable, useable in an emergency, or useable after improvement. A separate note should be made in the report giving the surface of the shoulders (grass, gravel, etc.), condition, width, vegetation, and critical side slopes.

- (c) *Construction material*. Various kinds of materials used for the normal route types (X, Y, and Z) and the symbols to be used in road-classification formulas are shown below. When normal route type has not been specifically designated as X, Y, or Z (road-

classification symbols *rb*, *nb*, *b*, or *v*), the analyst must make this determination. This will depend primarily upon the condition of facilities along the route. If the *v* symbol is used, a detailed description of the material must be included.

Normal route type	Material	Symbol
X	Concrete.....	k
X	Bituminous or asphaltic concrete (bituminous plant mix).	kb
X	Paving brick or stone.....	p
X or Y	Bitumen-penetrated macadam and waterbound macadam with superficial asphalt or tar cover.	rb
Y	Waterbound macadam, crushed rock, or coral.	r
Y	Gravel or lightly metalled.....	l
Y or Z	Bituminous-surface treatment on natural earth, stabilized soil, sand-clay or other select material.	nb
Z	Natural earth, stabilized soil, sand-clay, shell, cinders, disintegrated granite, or other select material.	n
X, Y, or Z	Use for bituminous surface when the type of bituminous construction cannot be determined.	b
X, Y, or Z	Material not mentioned above...	v

(d) *Length*. The length of the road is expressed in miles (mi) or kilometers (km). When included in the formula, the figure indicating the length of the road is placed in parentheses next to last item.

(e) *Obstructions*. In addition to showing an obstruction by (Ob) in the classification formula, the following obstructions which affect the traffic capacity of a road are reported, showing details of the obstruction and the location. When possible, these obstructions are shown by symbols on maps or overlays. Symbols conform to those shown in figure 3.5 below.

1. Overhead clearances which are less than 14 feet (4.25 meters) for tunnels, bridges, overhead wires, overhanging buildings, trees, or any other obstruction. (In areas where the overhead clearance is other than 14 feet, this other figure must be specified.)

2. Reductions in road widths, such as craters, narrow bridges, archways,

and buildings, which limit traffic capacity. (Critical road widths are specified by the commander concerned.)

3. Excessive gradients (7 percent and above) and excessive changes in gradients.

4. Curves which probably cannot be negotiated by heavy vehicles with trailers (radii of less than 100 feet or 30 meters).

5. Fords, indicating length and width of crossing and depth and nature of bottom.

6. Ferries, indicating length and width of crossing and capacity.

(f) *Snow blockage and flooding*. When these conditions are regular, recurrent, and serious, they are shown last in the road-classification formula as indicated for routes in *a* above.

(g) *Bridge information*. Bridge information is reported by the use of appropriate symbols and descriptions on a map or overlay.

(h) *Road designation*. Civil or military road numbers or other designations should be included in the information reported. On maps or overlays, the road number or other designation is placed as shown in figure 3.5.

(i) *Cover*. Cover suitable for parking and camouflage should be included in the information reported. When shown on maps or overlays, the symbols used for cover conform to those shown in figure 3.5.

(j) *Leaving road*. The ability to drive off the road (including shoulders) is included in the information reported. Normally, the information is needed only in conjunction with cover and is indicated by an arrow superimposed on the cover symbol as shown in figure 3.5. It may not be possible to leave the road because of embankments, cuttings, deep ditches, etc.

(2) *Road-classification formula*. The characteristics of the road are expressed in the order of limiting factors, width, construction material, length (if desired), obstructions, and snow blockage or flooding. The formula is prefixed by the symbol *A* if

there are no limiting factors and by the symbol *B* if there are limiting factors. If a limiting factor is unknown, it is expressed by placing a question mark after the appropriate symbol, thus: (*f?*). On maps and overlays, the terminal points of the road sector described are indicated by the symbol *V*.

c. Obstruction Symbols.

- (1) *A 5.0/6.2m k*. This describes a road with no limiting factors, 5.0 meters wide in the travelled way, 6.2 meters wide including shoulders, and constructed of concrete.
- (2) *A 12/14 ft kb (Ob)*. This describes a road with no limiting factors, 12 feet wide in the travelled way, 14 feet wide including shoulders, constructed of bituminous concrete, and having at least one obstruction not listed as a limiting factor.
- (3) *Bgs 14/16 ft 1 (Ob)*. This describes a road with obstructions (steep gradients above 7 percent), a rough surface, 14 feet wide in the travelled way, 16 feet wide including shoulders, and constructed of gravel or lightly metallated material.
- (4) *Bc (f?) 3.2/4.8m p (4.3km) (Ob) (T)*. This describes a road with obstructions (sharp curves), unknown foundation, 3.2 meters wide in the travelled way, 4.8 meters wide with shoulders, constructed of paving brick or stone, 4.3 kilometers long, and subject to snow blockage.

3.12 Bridge Signs

a. Circular Signs (figs. 3.6 and 3.7). These are placed at bridges to indicate the bridge classification. The signs have a yellow background; the bridge classification and appropriate symbol are in black.

b. Rectangular Signs (figs. 3.8 and 3.9). These signs give additional instructions and technical information. Minimum size is 16 inches high or wide. They have a yellow background and black symbols and lettering.

3.13 Bridge and Vehicle Weight Classification

a. Posting Bridges. Every military bridge is posted with a number indicating the highest vehicle weight class that can cross safely. Vehicles

of higher weight class are barred except for special crossings. Fixed bridges may also be marked with the length in feet of the span to which the posted capacity applies.

b. Marking Vehicles. Self-propelled vehicles in class 3 or higher and towed vehicles in class 1 or higher are marked to indicate the class, except that prime movers are marked with either their own class or the class of the normal combination of prime mover and trailer or semitrailer. Markings on the front of trucks should be on the right front, on or above the bumper, but below the driver's vision. Examples of vehicle markings are shown in figure 3.10.

c. Determining Vehicle Classes. The class of each standard vehicle and combination can be found in FM 5-36 and other Department of the Army publications on the subject such as training circulars and technical bulletins.

3.14 International (Geneva Convention) Road Signs

The road signs discussed in this paragraph were agreed upon at the United Nations Conference on Road and Motor Transport in 1949. Although these signs are not military, Army personnel should be familiar with them since they are used in Europe.

a. Dimensions of Signs. Dimensions of various signs are standardized in each country to insure maximum uniformity. In general, two sizes are used for each type of sign—a standard size and a reduced size for use where conditions do not permit or the safety of road users does not require erection of the standard size. In exceptional circumstances, a small sign may be used inside built-up areas or for repetition of the main sign.

b. Danger Signs (Class I) (fig. 3.11). Danger signs are in the shape of an equilateral triangle with one point upward, except in the case of the sign PRIORITY ROAD AHEAD which has one point downward. These signs have red borders with white or yellow backgrounds. Symbols are black or some other dark color. For signs of standard size, the length of each side of the triangle is not less than 2 feet 11.4 inches (0.90 of a meter), and, for the reduced size, not less than 1 foot 11.6 inches (0.60 of a meter). Signs are not more than 7 feet 2.6 inches (2.20 meters) above the ground at the highest point. Away from built-up areas, they are not less than 1 foot 11.6 inches (0.60 of a meter) above the ground at the lowest point.

			(1) SHARP CURVE (RADIUS IN FEET OR METERS)
			(2) STEEP GRADE (ARROWS POINT UPHILL) (GRADE IN PERCENT) (LENGTH OF ARROWS MAY SHOW LENGTH OF GRADE WHEN SCALE ALLOWS)
			(3) CONSTRICTION (WIDTH IN FEET OR METERS)
			(4) ARCH CONSTRICTION (WIDTH ON LEFT & HEIGHT ON RIGHT IN FEET OR METERS)
			(5) UNDERPASS CONSTRICTION (WIDTH ON LEFT & HEIGHT ON RIGHT IN FEET OR METERS)
			(6) BYPASS EASY
			(7) BYPASS DIFFICULT
			(8) BYPASS IMPOSSIBLE
			(9) LEVEL CROSSING
			(10) FORD (LENGTH, WIDTH, BOTTOM & DEPTH)
			FERRY (LENGTH, WIDTH, LOAD-CAPACITY)
			TUNNEL (LENGTH, WIDTH, HEIGHT)
			(11) ROAD BLOCK
			(12) ROAD BLOCK (READY TO USE BUT NOT IN POSITION)
			(13) PROPOSED ROAD BLOCK
			(14) LIMITS OF SECTOR
			(15) CIVIL OR MILITARY ROUTE DESIGNATION
			(16) COVER (ROAD LINED WITH TREES) (DECIDUOUS-LEFT) (EVERGREEN-RIGHT)
			(17) COVER (WOODS) (DECIDUOUS-LEFT) (EVERGREEN-RIGHT) ARROW DENOTES POSSIBILITY OF DRIVING OFF THE ROAD INTO DECIDUOUS COVER
			(18) CRITICAL POINT
			(19) THE LETTER IDENTIFIES THE PHOTO, AND THE APEX OF THE "L" ORIENTS IT AT POINT OF EXPOSURE

Figure 3.5. Symbols used to represent obstructions.

Signs are so placed that they are clearly visible, but do not impede pedestrians.

c. *Signs Giving Definite Instructions (Class II).* The signs of this class indicate an order, which may be either in the nature of a prohibition or an obligation (fig. 3.12). They are circular with a diameter of at least 1 foot 11.6 inches (0.60 of a meter) for

signs of standard size, and at least 1 foot 3.7 inches (0.40 of a meter) for signs of reduced size. They are placed in the immediate vicinity of the point where the prohibition or obligation begins and at intervals along the route. They are not more than 7 feet 2.6 inches (2.20 meters) above the ground at the highest point, and not less than 1 foot 11.6

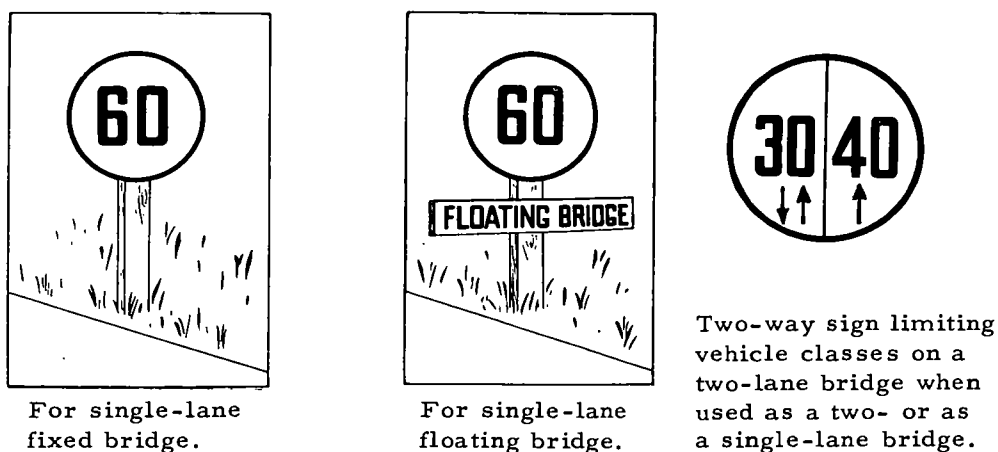


Figure 3.6. Typical bridge-class and information signs.

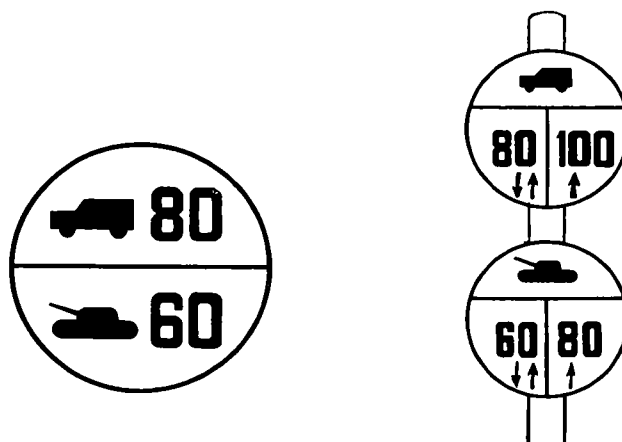


Figure 3.7. Typical dual-class bridge signs.

inches (0.60 of a meter) above the ground at the lowest point.

- (1) *Prohibitory signs (Class II A)*. These signs are white or light yellow with red borders, and the symbols are black or some other dark color. Examples of signs in this category are:

- (a) Prohibitions for all traffic.
- (b) Prohibitions for certain classes of vehicles.
- (c) Restrictions on the dimensions, weight, or speed of vehicles.

- (2) *Mandatory signs (Class II B)*. These signs are blue with white symbols. Examples of mandatory signs are—

- (a) A direction to be followed.
- (b) Where cyclists must ride.

- d. *Informative Signs (Class III)*. Signs of this

class are rectangular. Where the colors are not specifically prescribed, red does not dominate.

- (1) *Indication signs (Class III A)*. Signs of this type are used to indicate parking areas, hospitals, first-aid stations, telephones, filling stations, and priority roads (fig. 3.13). These signs have blue backgrounds, except those indicating priority roads which are white with black or dark rims on the outside and have yellow centers. Priority road signs are square with one point downward. The side of the square is at least 1 foot 11.6 inches (0.60 of a meter) for the standard size, and at least 1 foot 3.7 inches (0.40 of a meter) for the reduced size. For signs repeated within built-up areas, the side of the square is 9.8 inches (0.25 of a meter).

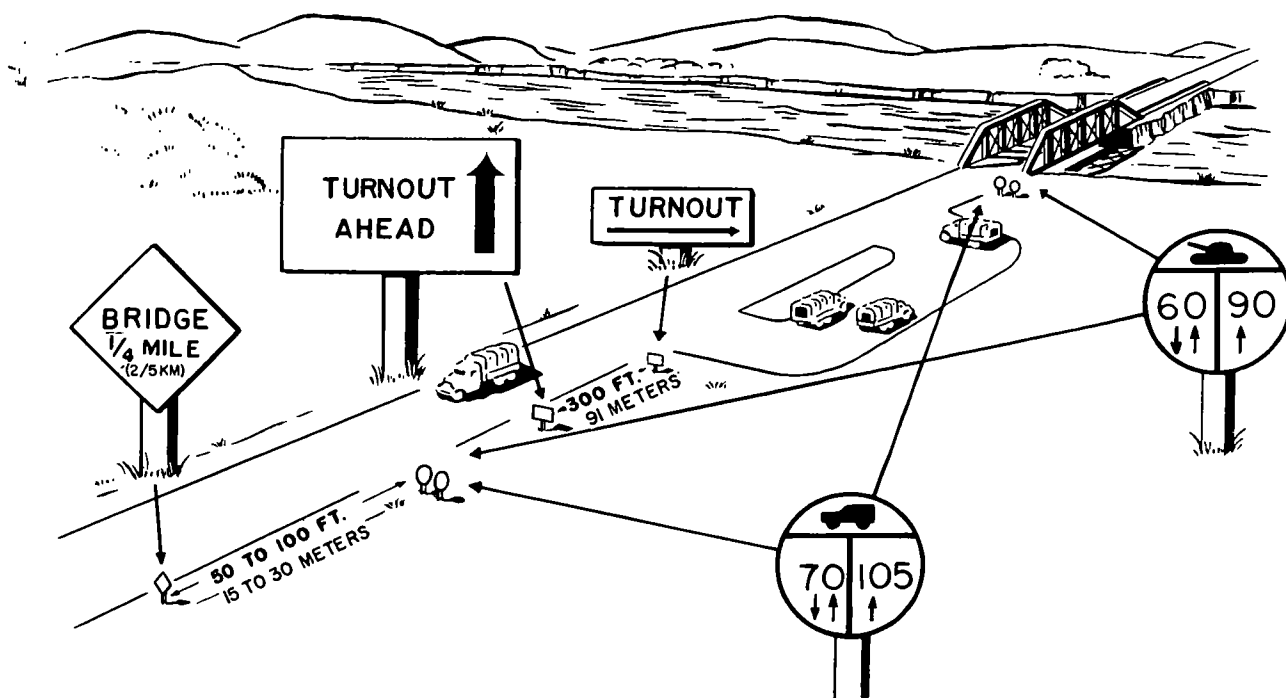


Figure 3.8. Typical arrangement of road-guide, information, and two-lane bridge-class signs.

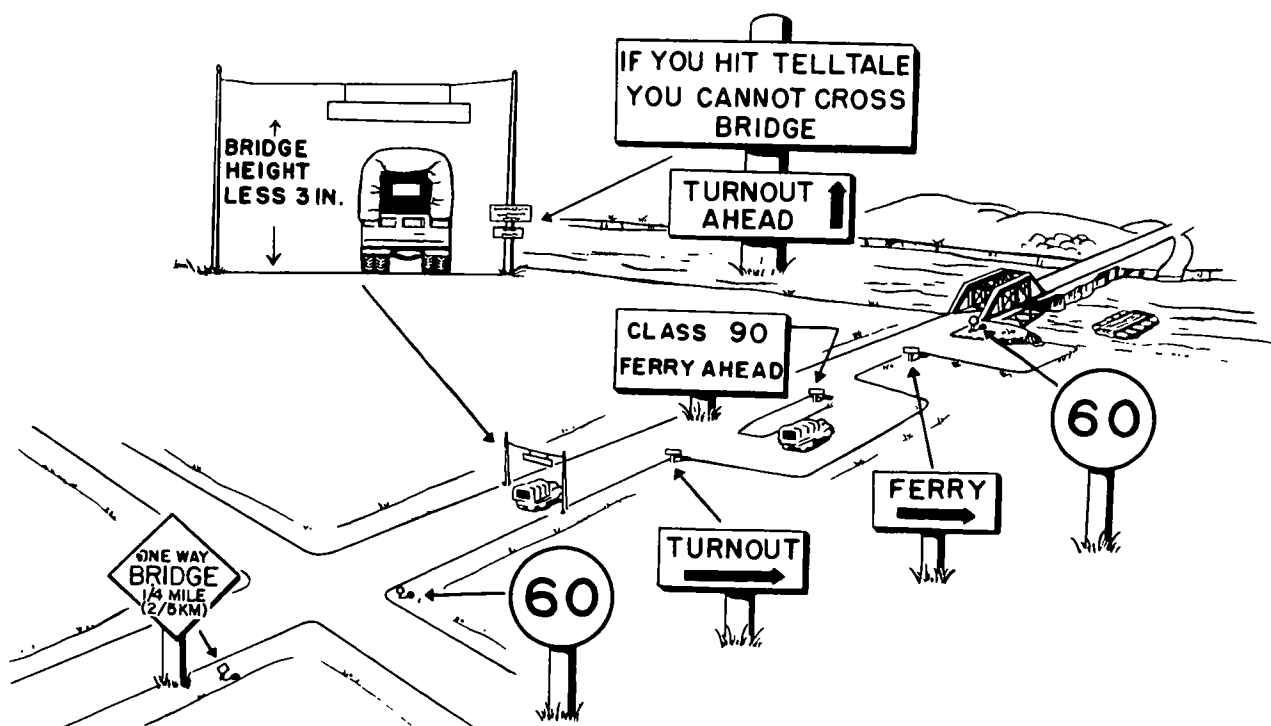


Figure 3.9. Typical arrangement of road-guide, information, single-lane bridge-class signs.

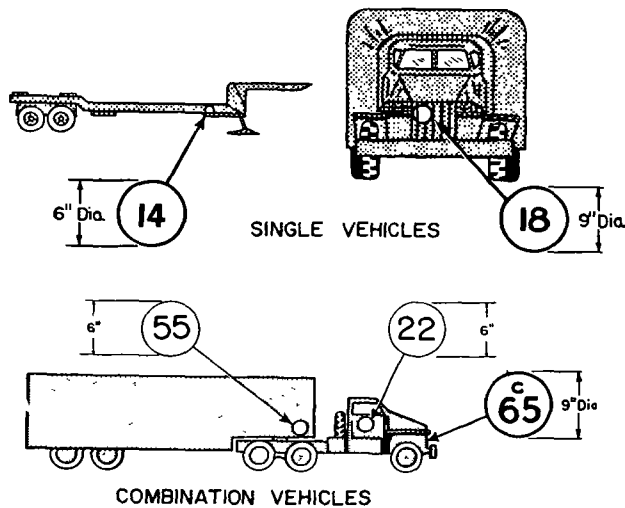


Figure 3.10. Vehicle weight classification marking.

- (2) *Advance direction signs and direction signs (Class III B).* The size of these signs is such that the indication can be understood easily by drivers in time to enable them to comply. They have either light backgrounds with dark lettering or dark backgrounds with light lettering. Advance direction signs are placed at a distance of between 328 feet (100 meters) and 820 feet (250 meters) from the intersection on normal roads. On special roads; e.g., concrete multilane roads, this distance is increased to 1,640 feet (500 meters). Direction signs are rectangular with the longer side horizontal and end in an arrowhead. Names of places lying in the same direction may be added to the sign. Colors of these signs are the same as for advance direction signs. When distances are indicated, the figures giving distances are inscribed between the name of the place and the arrowhead.
- (3) *Place identification signs (Class III C).* Signs indicating a locality are rectangular with the longer side horizontal. They are of such size and location that they are visible at night. They have either light backgrounds with dark lettering, or dark backgrounds with light lettering. They are placed before the beginning of a built-up area, and at other points necessary to indicate place locations.

3.15 NATO Military Road Signs

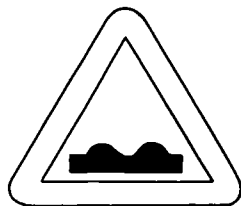
To facilitate the movement of armed forces of the North Atlantic Treaty Organization (NATO) in any territory controlled by operational military command or a national authority, a standard system of military route signs has been adopted by member governments. This system includes signs which the Geneva Convention already prescribes (par. 3.14) and others not included in the Geneva Convention. Standard signs include hazard signs, regulatory signs, and guide signs. Examples are shown in figure 3.14.

a. Hazard Sign. This sign indicates a traffic hazard and is used only in areas under military authority. A hazard sign is square and is placed with one corner pointing downward. A purely military sign not included in the International (Geneva Convention) or host country's system has a yellow background with the legend or symbol in black. If the sign is included in the International or host country's system, the International or host-country sign is used on the same yellow background instead of the black symbol or legend.

b. Regulatory Sign. This sign is used to regulate and control traffic. A regulatory sign is square. It has a black background on which the legend is superimposed in white with the following exceptions: bridge classification signs, stop signs, no-entry signs, and signs erected by the military for the control of civilians under specified circumstances.

c. Guide Sign. A guide sign is used to indicate locations, distances, directions, routes, and similar information.

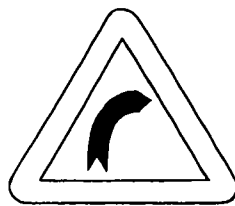
- (1) A guide sign for a route is rectangular with the long axis vertical. The legend or symbol and route number are superimposed in white on a black background. Odd numbers are used for axial routes, and even numbers described lateral routes.
- (2) A directional disk is used as a supplement to other guide signs to indicate the direction of a route or as an appendage to any major-unit sign to indicate the route to that unit. The disk is less than 16 inches (0.41 meters) in diameter and has a black arrow, with or without bar, on a white background. Eight equally spaced holes around its circumference allow the disk to be nailed with the arrow pointing in



UNEVEN ROAD



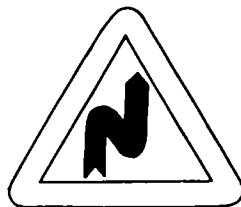
DANGEROUS BEND



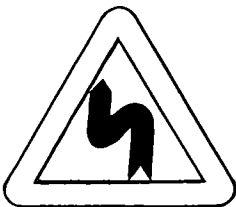
RIGHT BEND



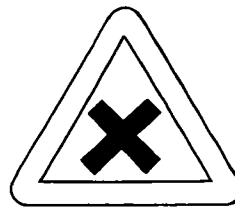
LEFT BEND



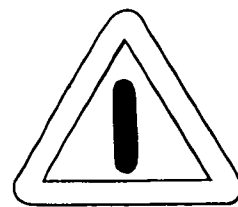
DOUBLE BEND
(FIRST TO THE RIGHT)



DOUBLE BEND
(FIRST TO THE LEFT)



ROAD INTERSECTION



OTHER DANGER



OPENING BRIDGE



ROAD REPAIR



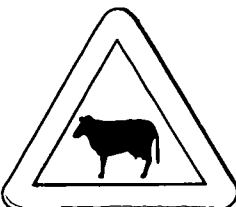
SLIPPERY ROAD



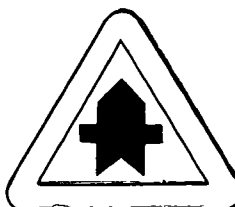
PEDESTRIAN
CROSSING



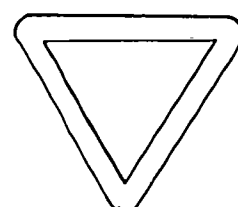
CHILDREN



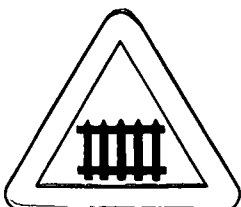
BEWARE OF
ANIMALS



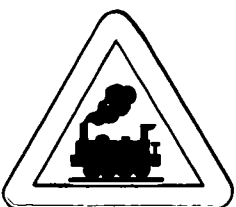
INTERSECTION
WITH NON-PRIORITY
ROAD



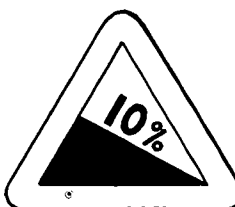
PRIORITY ROAD
AHEAD



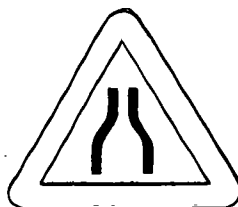
LEVEL R.R. CROSSING
WITH GATES



LEVEL CROSSING
WITHOUT GATES
(APPROACH SIGN)



DANGEROUS HILL

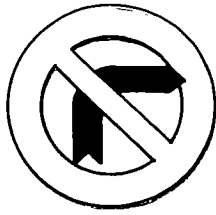


ROADWAY NARROWS

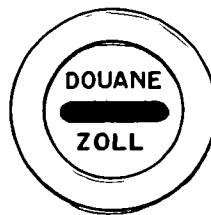
Figure 3.11. International road signs—danger.



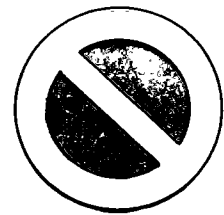
STOP AT
INTERSECTION



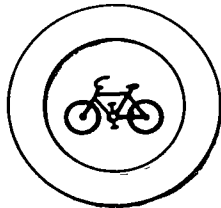
NO RIGHT TURN



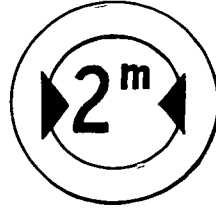
STOP- CUSTOMS



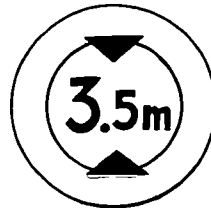
NO STOPPING
OR WAITING



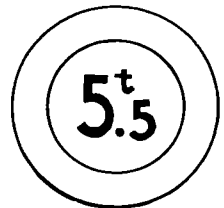
BICYCLES
PROHIBITED



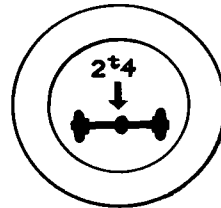
NO ENTRY FOR VEHICLES
HAVING OVERALL WIDTH
EXCEEDING 2 METERS



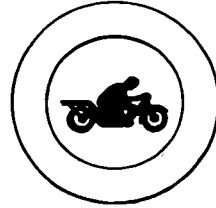
NO ENTRY FOR VEHICLES
HAVING OVERALL HEIGHT
EXCEEDING 3.5 METERS



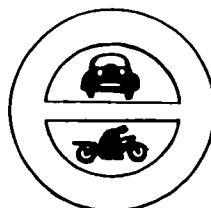
NO ENTRY FOR VEHICLES
EXCEEDING 5.5 TONS
GROSS WEIGHT



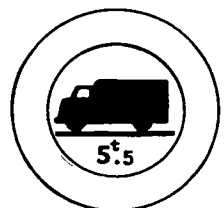
NO ENTRY FOR VEHICLES
WITH AN AXLE WEIGHT
EXCEEDING 2 TONS



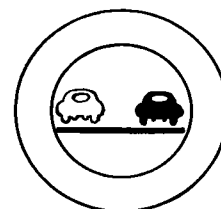
NO ENTRY FOR
MOTORCYCLES
W/O SIDECARS



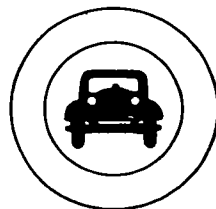
NO ENTRY FOR
ALL MOTOR
VEHICLES



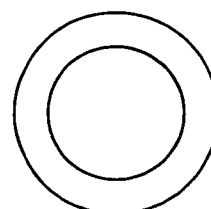
NO ENTRY FOR GOODS
CARRYING VEHICLES
EXCEEDING 5.5 TONS
LADEN WEIGHT



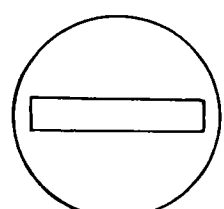
NO PASSING



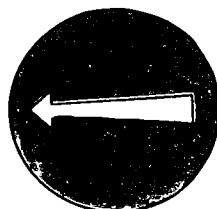
NO ENTRY FOR ALL
VEHICLES EXCEPT
MOTORCYCLES W/O
SIDECARS



CLOSED TO ALL
VEHICLES



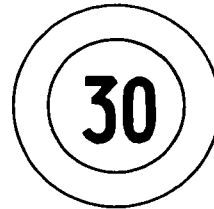
NO ENTRY FOR
ALL VEHICLES



TURN LEFT

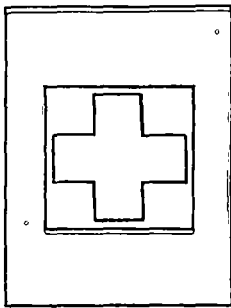


COMPULSORY CYCLE
TRACK

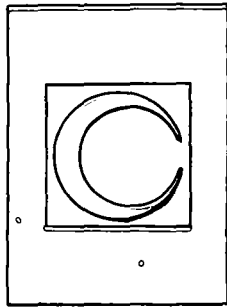


SPEED LIMIT

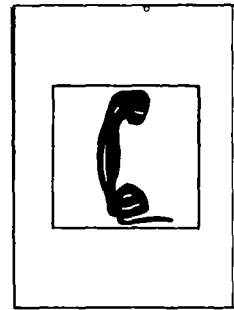
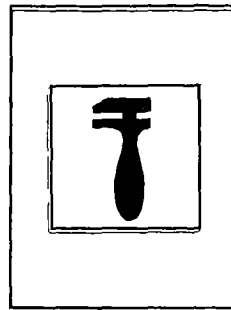
Figure 3.12. International road signs—definite instructions.



FIRST-AID STATION



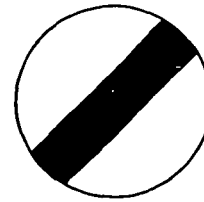
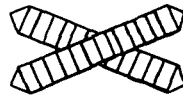
MECHANICAL HELP



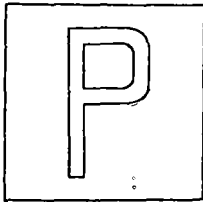
TELEPHONE



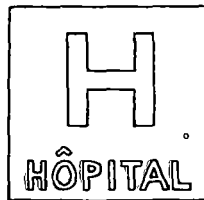
LEVEL R.R. CROSSING WITHOUT
GATES IN IMMEDIATE VICINITY



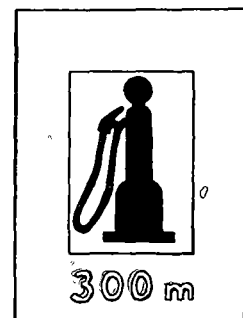
END OF SPEED LIMIT



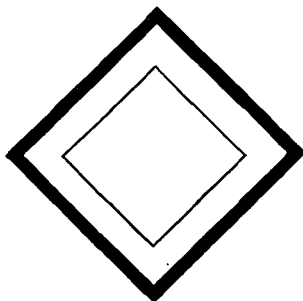
PARKING
PERMITTED



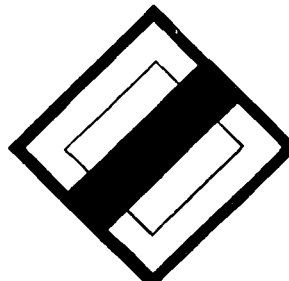
HOSPITAL



FILLING STATION

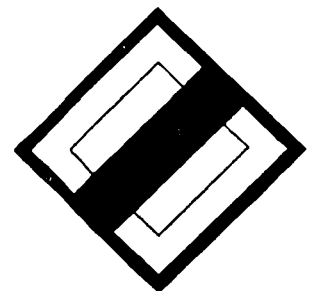


PRIORITY ROAD



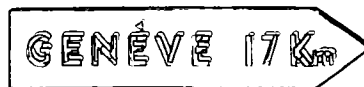
200m

APPROACH TO END OF
PRIORITY ROAD

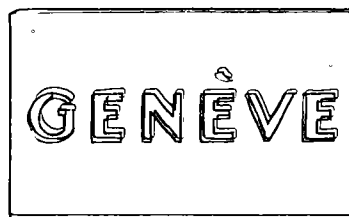


END OF PRIORITY ROAD

Figure 3.13. International road signs—informative.



DISTANCE SIGNS

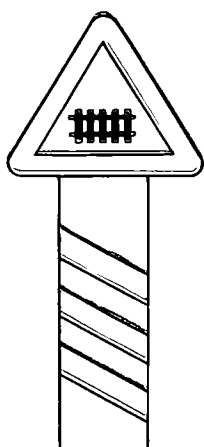


LOCALITY SIGNS

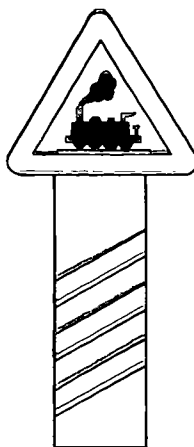


DIRECTION SIGNS

MILESTONE



A



B



C



D

SUPPLEMENTARY RAILWAY SIGNS

IF SIGN A OR SIGN B IS DISPLAYED, IT MUST BE FOLLOWED BY SIGN C AND THEN SIGN D, INDICATING 2/3 AND 1/3 OF THE DISTANCE TO THE DESIGNATED POINT DESCRIBED IN THE ORIGINAL SIGN.

Figure 3.13.—Continued.

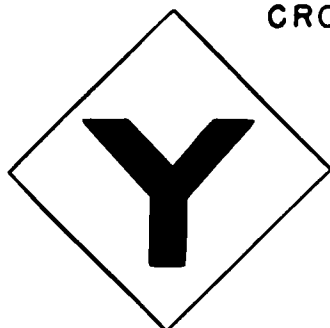
HAZARD



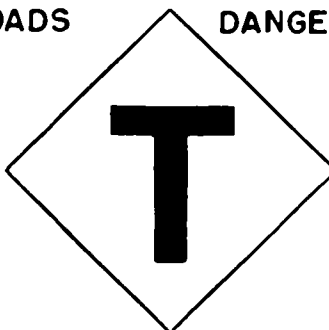
CROSSROADS



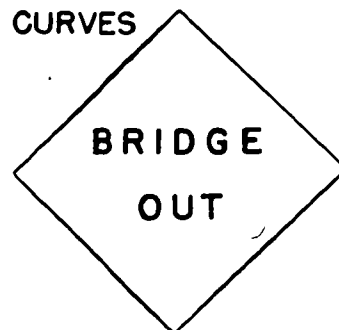
DANGEROUS CURVES



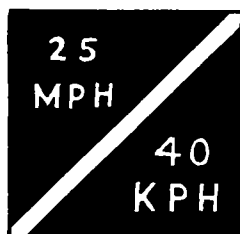
Y-JUNCTION



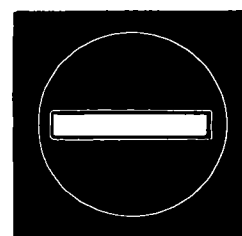
T-JUNCTION



REGULATORY



SPEED LIMIT



NO ENTRY

DETOUR



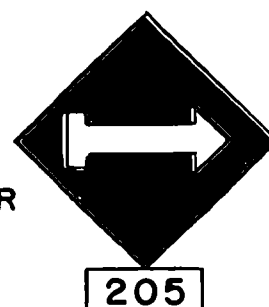
OR



DETOUR TO AXIAL
ROUTE 205 TO FRONT,
TURN RIGHT



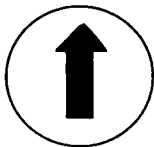
OR



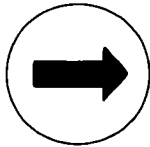
DETOUR TO AXIAL
ROUTE 205 TO REAR,
TURN RIGHT

Figure 3.14. NATO military road signs.

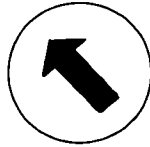
DIRECTIONAL DISK



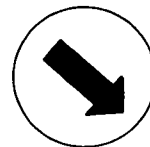
STRAIGHT AHEAD



TURN RIGHT



FORK LEFT

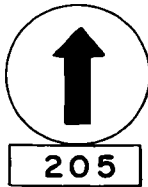


SHARP TURN
TO RIGHT REAR

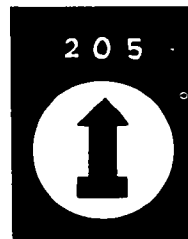
ROUTE



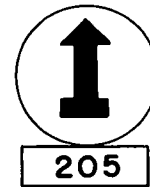
OR



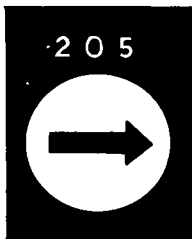
AXIAL ROUTE 205
TO FRONT, STRAIGHT AHEAD



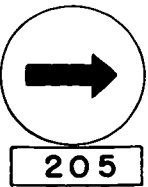
OR



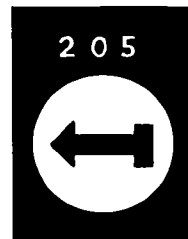
AXIAL ROUTE 205
TO REAR, STRAIGHT AHEAD



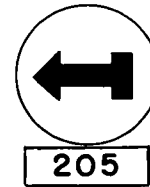
OR



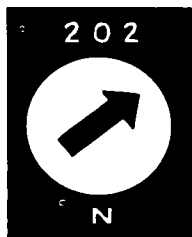
AXIAL ROUTE 205
TO FRONT, TURN RIGHT



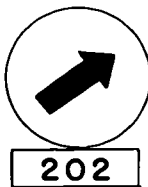
OR



AXIAL ROUTE 205
TO REAR, TURN LEFT



OR

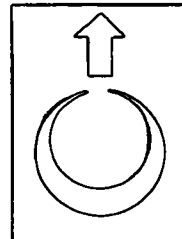
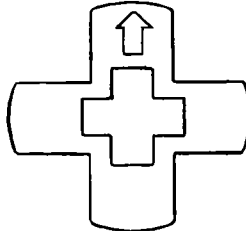
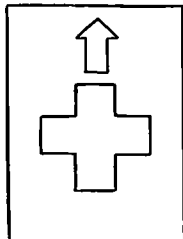


LATERAL ROUTE 202
NORTH-BOUND TRAFFIC
TO FRONT, FORK RIGHT



DETOUR

CASUALTY EVACUATION ROUTE



(ALL MEDICAL UNITS EXCEPT TURKISH) (TURKISH MEDICAL UNITS)

Figure 3.14.—Continued.

any direction. Battalions and lower units are not permitted to install directional disks.

- (3) A guide sign for a casualty evacuation route is either rectangular or cross-shaped with symbols in red on a white background.
- (4) A detour sign has a white arrow, barred or not, on a blue square. The sign is placed so that one corner of the square points downward.

3.16 NATO Markings for Military Vehicles

a. General. The armed forces of NATO have agreed to use the standard markings for vehicles described below. The markings listed are not necessarily used at all times, but, when they are used, vehicles are marked in accordance with the following paragraphs. The rear of a trailer is marked in the same way as its prime mover; there is no need to mark the front of a trailer. When necessary for security reasons, vehicle marking may, by direction of the field commander or his superior authority, be covered or removed.

b. Registration Numbers. The marking of vehicles for registration is as required by the nation concerned. Registration markings consist of numbers or a combination of letters and numbers.

c. National Symbols. National symbols are used to identify the vehicles of each country. At a minimum, symbols are shown front and rear. Service symbols may be superimposed upon the national distinguishing symbols or shown separately by an additional symbol.

d. Speed Limits. Speed limit markings are placed on vehicles as directed by the nation concerned.

e. Tactical. Tactical markings serve in general as identification markings within units; they consist of stripes and geometrical figures or combinations thereof and may also include a name. Colors may be used. Markings should be large enough to make ground-to-ground identification of vehicles possible: they are used primarily for easy battle-field recognition. The design and position of these markings are prescribed by the field commander directing their use. They are removed when vehicles are permanently released from the jurisdiction of the commander who prescribed their use.

f. Air-Ground Recognition. Equipment for these markings consists of red and yellow fluorescent panels equipped with tie cords. Panel dimensions

are approximately 6 feet by 2 feet 3 inches (1.80m by 0.68m). Panels are draped on vehicles in a standard, unchanging pattern that differs from the displays prescribed for other recognition purposes (front lines, targets, etc.). Theater commanders prescribe the arrangement of panels and the conditions under which they will be used.

g. Special. Military police vehicles and other traffic control vehicles are identified, front and rear, with the prescribed markings. Ambulances and other vehicles used exclusively for medical purposes are marked according to the rules of the Geneva Convention. Such markings consist of one red cross or crescent on a square white background painted on the side body panels, roof of body, roof of driver's cab, and rear door(s) or panel.

h. Bomb Disposal Units. Vehicles of bomb disposal units have all mudguards painted red.

i. Danger. A red flag flown from any vehicle indicates DANGER.

j. Priority Vehicles. Any vehicle which for any reason (special liaison officer, signal vehicles carrying priority dispatches, damage assessment personnel, etc.) requires priority over all other vehicles may be so marked by any commander having area responsibility. Such priority markings are valid only in the area of the commander concerned. The markings consist of equilateral triangles with red borders and symbols on white backgrounds on the front and rear of the vehicle (fig. 3.15). A single priority sign may be used if visible from both front and rear. The size of a

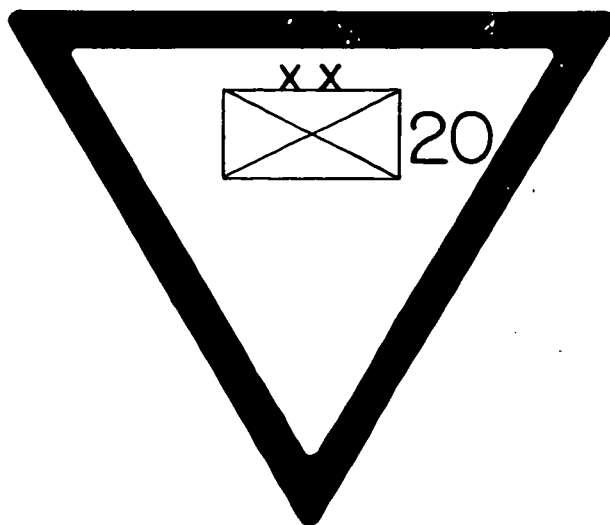


Figure 3.15. Vehicle priority sign.

priority sign should be as large as the dimensions of the vehicle permit. The symbol inside the triangle indicates the commander authorizing use of this priority sign. This sign must be removable in order to avoid misuse and is used only on direct orders of the commander concerned.

k. Movement Serials.

- (1) A movement serial is an element or group of elements within a series which is given a numerical or alphabetical designation for convenience in planning, scheduling, or controlling vehicle movements.
- (2) The leading vehicle of each movement serial carries a blue flag.
- (3) The rear vehicle in the movement serial carries a green flag.
- (4) The vehicle of a movement serial commander displays a flag that is bisected by a diagonal line to form two triangles. The upper triangle is white; the lower is black.
- (5) In areas where vehicles drive on the left side of the highway, the flags are mounted on the right side of the vehicle; otherwise, they are mounted on the left side.
- (6) Flags are approximately 12 inches by 18 inches (30 cm by 45.7 cm).
- (7) The number or letter assigned to a movement serial is marked on the front and on both sides of each vehicle in the serial. The marking is placed so that it is clearly visible from the ground and does not interfere with other prescribed markings.

l. Illumination of Vehicle Markings. The condition under which military traffic moves at night is determined by the local command. The enemy threat and, so far as possible, the regulations of the host country are considered when deciding whether the illumination will be normal, reduced, or blacked out. Under normal lighting conditions, the military registration or identification number at the rear of a motor vehicle or trailer is so illuminated that it is readable at a minimum distance of 20 yards (18 meters). The local commander prescribes either reduced lighting or blackout when necessary.

3.17 Arm and Hand Signals

a. The safe operation of motor vehicles often depends upon the driver knowing and using the arm and hand signals shown in figure 3.16.

b. The current concept of tactical operations requires that vehicle drivers be trained to operate

their vehicles under blackout conditions and to recognize operational night hand signals (fig. 3.17). These signals provide a means of control at night or when radio silence and security requirements are at a maximum.

c. The arm and hand signals illustrated in figure 3.18 are the common means for transmitting visual messages within administrative and tactical units of the Armed Forces. They must be memorized and practiced until they become second nature. Visual signals are useless if not correctly and distinctly interpreted. The signals illustrated with a single-headed arrow indicate the signal is a single action which may be repeated until acknowledged or executed. Signals illustrated with a double-headed arrow are continuous until acknowledged or executed. For additional information, see FM 21-60.

3.18 Basic March Formulas¹

a. General. There are three basic march factors: distance (D), rate (R), and time (T). When two are known, the third can be found by using the formula shown below. Corresponding units of measure must be used throughout.

$$R = \frac{D}{T} \quad T = \frac{D}{R} \quad D = RT$$

b. Rate Factors.

$$\text{Rate (yards per minute)} = \frac{\text{length (yards)}}{\text{time length (minutes)}}$$

$$\begin{aligned} \text{Rate (meters per minute)} \\ &= \frac{\text{length (meters)}}{\text{time length (minutes)}} \end{aligned}$$

$$\begin{aligned} \text{Rate (miles in the hour (mih))} \\ &= \frac{\text{road distance (miles)}}{\text{time distance (hours)}} \end{aligned}$$

$$\begin{aligned} \text{Rate (kilometers in the hour (kmih))} \\ &= \frac{\text{road distance (kilometers)}}{\text{time distance (hours)}} \end{aligned}$$

c. Time Factors.

$$\begin{aligned} \text{Time length (minutes)} &= \frac{\text{length (yards)}}{\text{rate (yards per minute)}} \\ &= \frac{\text{length (meters)}}{\text{rate (meters per minute)}} \end{aligned}$$

$$\begin{aligned} \text{Time lead (minutes)} &= \frac{\text{lead (yards)}}{\text{rate (yards per minute)}} \\ &= \frac{\text{lead (meters)}}{\text{rate (meters per minute)}} \end{aligned}$$

¹ For time and space definitions, see FM 25-10.

$$\begin{aligned}\text{Time gap (minutes)} &= \frac{\text{gap (yards)}}{\text{rate (yards per minute)}} \\ &= \frac{\text{gap (meters)}}{\text{rate (meters per minute)}}\end{aligned}$$

$$\begin{aligned}\text{Time space (hours)} &= \frac{\text{road space (miles)}}{\text{rate (mih)}} \\ &= \frac{\text{road space (kilometers)}}{\text{rate (kmih)}}\end{aligned}$$

$$\begin{aligned}\text{Time distance (hours)} &= \frac{\text{road distance (miles)}}{\text{rate (mih)}} \\ &= \frac{\text{road distance (kilometers)}}{\text{rate (kmih)}}\end{aligned}$$

d. Distance Factors.

$$\text{Length (yards)} = \text{rate (yards per minute)} \times \text{time length (minutes)}$$

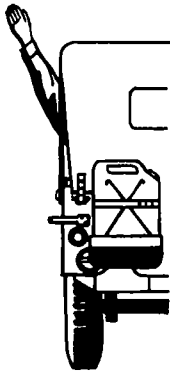
$$\text{Length (meters)} = \text{rate (meters per minute)} \times \text{time length (minutes)}$$

$$\text{Lead (yards)} = \text{rate (yards per minute)} \times \text{time lead (minutes)}$$

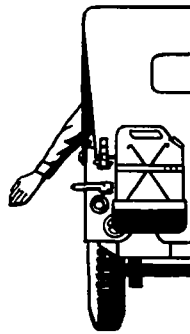
$$\text{Lead (meters)} = \text{rate (meters per minute)} \times \text{time lead (minutes)}$$

$$\text{Gap (yards)} = \text{rate (yards per minute)} \times \text{time gap (minutes)}$$

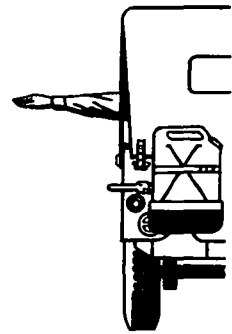
$$\text{Gap (meters)} = \text{rate (meters per minute)} \times \text{time gap (minutes)}$$



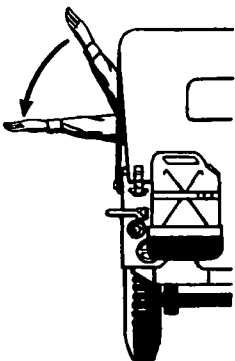
① RIGHT TURN



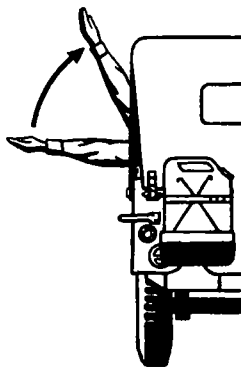
② STOP



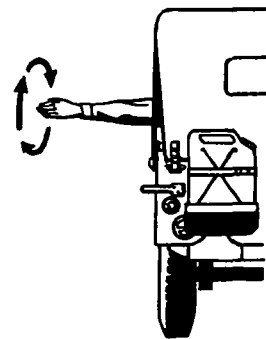
③ LEFT TURN



④ OPEN UP

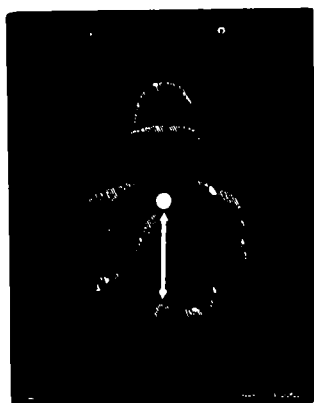


⑤ CLOSE UP

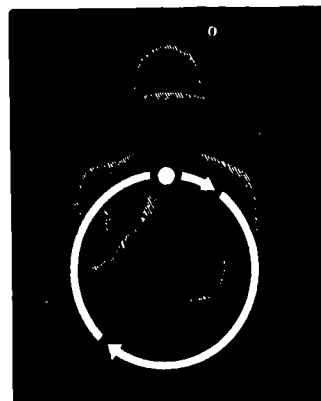


⑥ PASS AND KEEP GOING

Figure 3.16. Driver arm and hand signals.



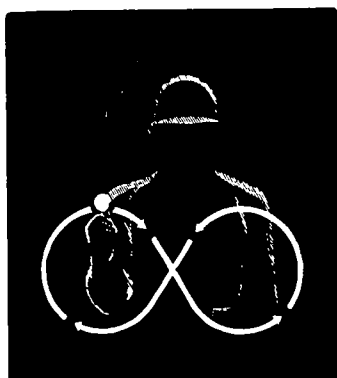
- ① Go; or Forward; or Move out; or Increase speed; or Double time. The light is moved several times vertically in front of the body.



- ② Turn right. The light is rotated clockwise (from the individual giving the signal).



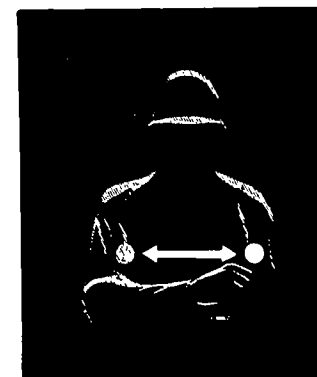
- ③ Turn left. The light is rotated counterclockwise (from the individual giving the signal).



- ④ Start engine(s). The light is so moved as to describe the figure 8 (on its side) in a vertical plane in front of the body of the individual giving the signal.



- ⑤ Move in reverse. The light is held at shoulder level and blinked several times toward the vehicle.



- ⑥ Stop; or Stop engine(s). The light is moved horizontally back and forth several times across the path of approaching traffic to stop traffic. The same signal is used to stop engines.

Figure 3.17. Night hand signals.



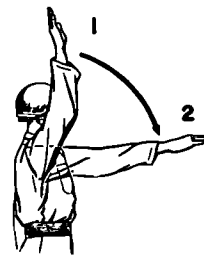
A. ATTENTION



B. ASSEMBLE



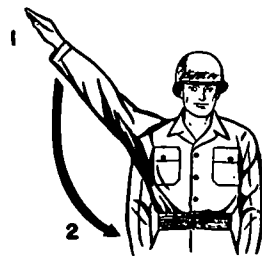
C. READY



D. FORWARD; OR TO THE REAR (Vehicles or individuals turn simultaneously)



E. MOUNT



F. DISMOUNT



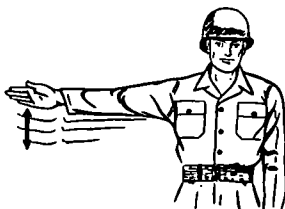
G. START ENGINE(S); OR PREPARE TO MOVE



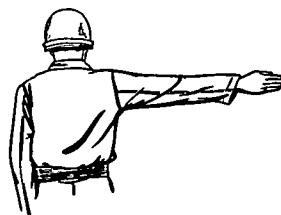
H. STOP ENGINE (S)



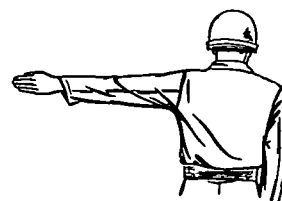
I. INCREASE SPEED; OR DOUBLE TIME; OR RUSH



J. DECREASE SPEED (Vehicles)



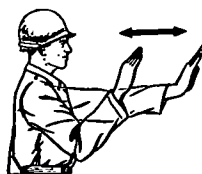
K. RIGHT TURN; OR COLUMN RIGHT



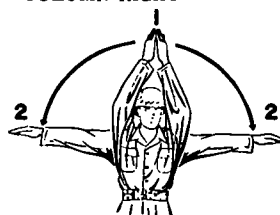
L. LEFT TURN; OR COLUMN LEFT



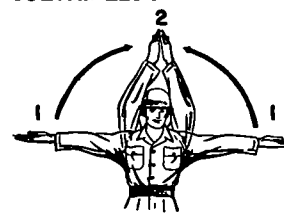
M. MOVE AHEAD; OR JOIN ME; OR FOLLOW ME



N. MOVE IN REVERSE



O. EXTEND (From Turret, Ground, or Open Vehicle)



P. CLOSE UP (From Turret, Ground or Open Vehicle)



Q. HALT; OR STOP



R. CLOSE UP AND STOP



S. DISREGARD PREVIOUS COMMAND; OR AS YOU WERE



T. VEHICLE OUT OF ACTION

Figure 3.18. Motor march hand and arm signals.

$$\begin{aligned}\text{Road space (miles)} &= \text{rate (mih)} \\ &\quad \times \text{time space (hours)} \\ \text{Road space (kilometers)} &= \text{rate (kmih)} \\ &\quad \times \text{time space (hours)} \\ \text{Road distance (miles)} &= \text{rate (mih)} \\ &\quad \times \text{time distance (hours)} \\ \text{Road distance (kilometers)} &= \text{rate (kmih)} \\ &\quad \times \text{time distance (hours)}\end{aligned}$$

e. *Time-Distance Factors* (fig. 3.19). When the speed in miles or kilometers per hour is known, the time in minutes or the distance in miles or kilometers travelled can be quickly determined from a time-distance graph (fig. 3.20). For example, if a convoy moves at a speed of 15 miles per hour (24.14 kmph) for a 2-hour period, the distance travelled can be determined by:

- (1) Locating the oblique line marked 15 mph (24.14 kmph).
- (2) Locating the horizontal line, extending from the left margin, representing the 2 hours travelled.
- (3) Determining the point at which these two

lines intersect and reading the distance in miles or kilometers from the scale along the bottom (miles) or top (kilometers) margin of the graph. For this example, the distance travelled would be 30 miles (48.27 km).

f. *Conversions.*

- (1) The following factors may be converted into distance, rate, or time by arithmetic:

$$\text{Length} + \text{gap} = \text{lead}$$

$$\text{Time length} + \text{time gap} = \text{time lead}$$

$$\text{Distance (miles)} \times 1,760 = \text{distance (yards)}$$

$$\begin{aligned}\text{Distance (kilometers)} \times 1,000 \\ = \text{distance (meters)}\end{aligned}$$

$$\text{Time (hours)} \times 60 = \text{time (minutes)}$$

$$\text{Rate (mih)} \times 30 = \text{approximate rate or speed (yards per minute)}$$

$$\text{Rate (kmih)} \times 17 = \text{approximate rate or speed (meters per minute)}$$

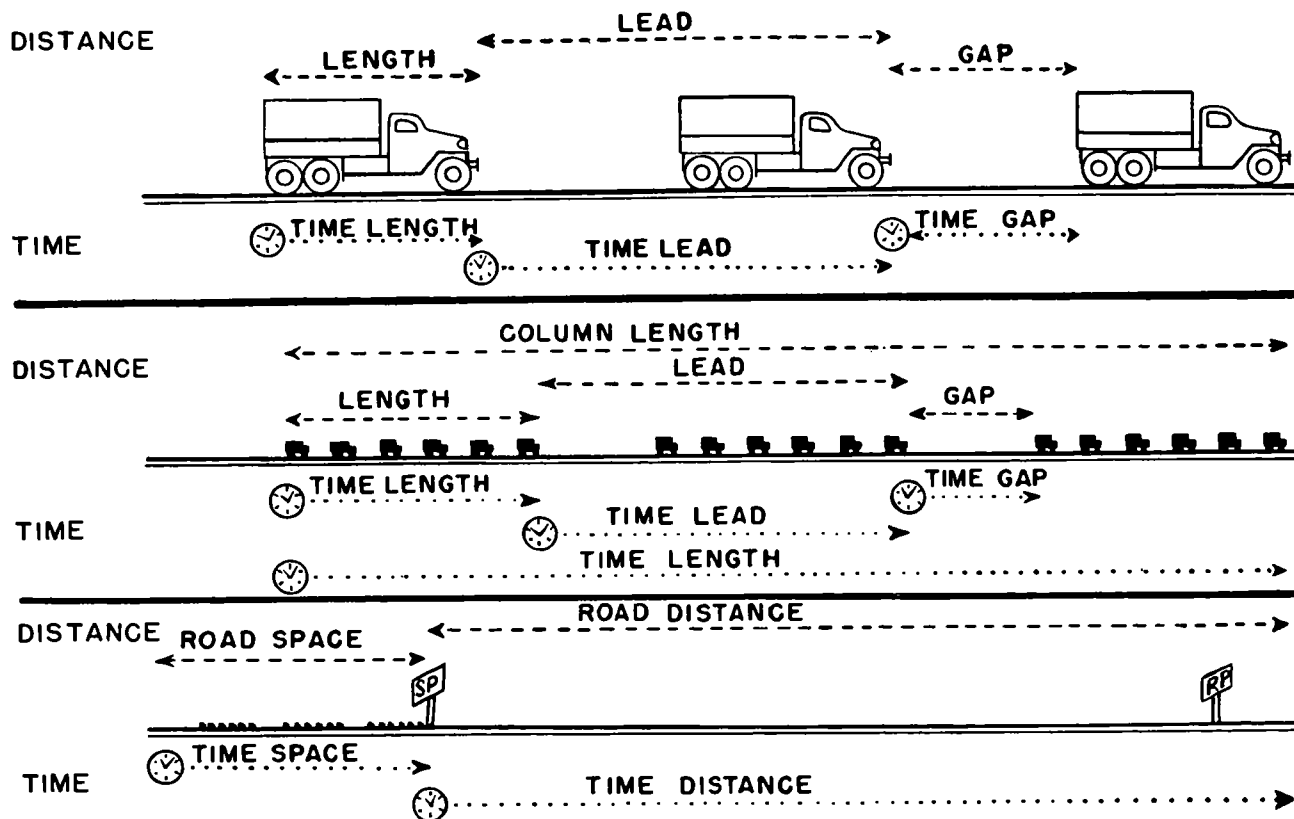


Figure 3.19. Space and time factors.

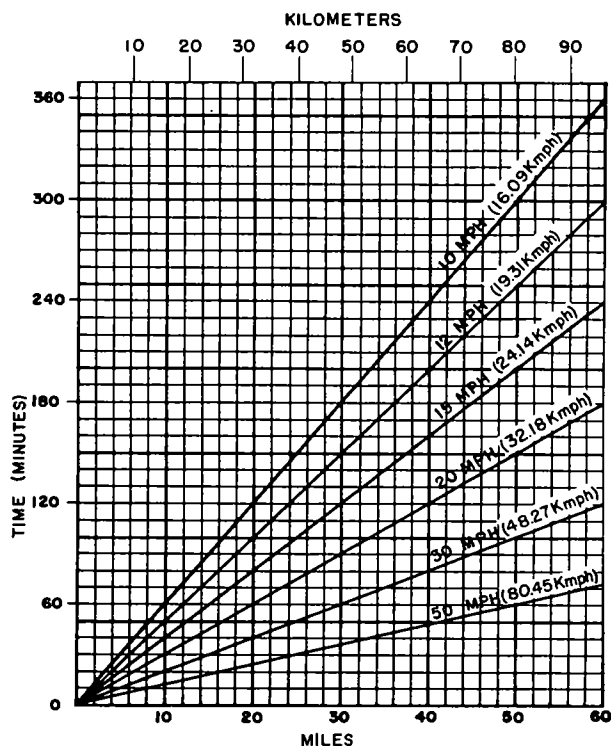


Figure 3.20. Time-distance graph.

- (2) These factors are substituted in the basic formulas in *a* through *d* above. For example:

Time length (minutes)

$$= \frac{\text{miles} \times 1,760}{\text{mih} \times 30}$$

$$= \frac{\text{kilometers} \times 1,000}{\text{kmih} \times 17}$$

Speed (yards per minute)

$$= \frac{\text{miles} \times 1,760}{\text{hours} \times 60}$$

Speed (meters per minute)

$$= \frac{\text{kilometers} \times 1,000}{\text{hours} \times 60}$$

3.19 Basic Lengths

The length of any column or element of a column is the length of roadway which it occupies, measured from front to rear inclusive. For planning purpose the average length of 1 motor transport vehicle is 10 yards (approximately 9 meters).

3.20 Road-Movement Graph

a. Definition. A road-movement graph (fig. 3.21) is a time-space diagram used in controlling

both foot and road marches and in preparing or checking road-movement tables. The graph helps the planner to foresee possible conflicts and discrepancies in planning.

b. Uses. Road-movement graphs may be used to indicate—

- (1) Position of various mixed traffic on a route at a particular time.
- (2) Scheduled passing of various elements of traffic at a particular point.
- (3) Conflicts between various elements of traffic at junctions, intersections, bridges, and defiles.
- (4) Deviations of columns from prescribed schedule.
- (5) Reversing directions of march, either by simultaneous turn of all elements of a column or by circling about.
- (6) Two-way traffic over a route and alternating traffic through defiles.
- (7) Variations in actual running speeds and in the traffic flow and traffic density of a route.

c. Construction.

- (1) Analyze the route on the map. Note important points such as cities, towns, road junctions, bottlenecks, etc., to be passed through and the distance between major points along the route.
- (2) Select graph paper with enough squares to plot distance and time involved. Across bottom, left to right, place scale of time. In left margin, from bottom to top, place scale of distance.
- (3) If the origin and destination, rate of march, and time of departure of a movement are known, schedule the head of the column as follows:
 - (a) Assume that a unit is to march from Mount Royal (25 miles (40.2 kilometers) on the vertical scale), leaving 0700 hours and proceeding at 15 miles in the hour (24.1 kmih) to a point 5 miles (7.4 km) beyond Tavistock. The distance is 60 miles (96.5 km). At 15 miles in the hour, it will require 4 hours to cover the 60 miles.
 - (b) Place a dot at the point where the line representing the place of departure (Mount Royal at 25 miles on the vertical scale) intersects the line representing the hour of departure (0700 hours on horizontal scale).

- (c) Place a second dot at the point where the line representing the destination (5 miles past Tavistock at the 85-mile (136.7 km) mark on the vertical scale) intersects that of hour of scheduled arrival of the head of the column at the destination (1100 hours on the horizontal scale or 0700 plus 4 hours).
- (4) Unless the unit is very small, usually it is desirable to show the schedule of the tail of the column as well as the head. After charting the schedule of the head, schedule the tail if the time length of the column is known or can be computed. Assuming that the time length of the column, including extra time allowance, is 30 minutes, a line drawn from the point representing the clearance of the column at origin (0730) and at the destination (1130) will be shown the schedule of the tail of the column past all points on route.
- (5) To determine what time the column must start to complete the movement and arrive at the destination at a certain hour, reverse the above procedure.

d. Analysis. Length, time length, rate of march, and other factors may be determined from the road-movement graph as follows:

- (1) *Length of column.* A vertical line connecting the head and tail lines, measured by the scale of miles or kilometers, will show the planned length of the column on the road at the prescribed rate of march at any hour during the movement, provided that the extra time allowance, if any, converted to distance is subtracted from the measurement.

EXAMPLE: When the head of the column is at Stevens (45 miles (72.4 km) on vertical scale), the tail will be at approximately the 38-mile (61.1 km) mark.

- (2) *Time length.* A horizontal line connecting the head and tail lines, measured by the scale of hours, will show the planned time length of the column as it passes any point on the road.

EXAMPLE: If the head of the column arrives at Tavistock at 1040 hours, the tail will not clear that point until half an hour later, at 1110 hours.

- (3) *Rate of march.* The diagonal line of the graph indicates the rate of march.

EXAMPLE: The distance (mile or kilometer scale) between the intersection of the diagonal line with any two vertical lines spanning a 1-hour period (time scale) indicates the distance in *that* hour.

e. Multiple Movements.

- (1) A number of serials or columns over the same route can be scheduled by using a road-movement graph. The commander of a large unit or the highway regulation officer can keep accurate records of the location of each serial by having information sent to him as each serial reaches or clears highway regulation points along the route of march. This information is indicated by filling in the space between the lines representing the scheduled head and tail of each column with color or tape. This enables the headquarters to see at a glance the location of each serial, to follow the progress of each movement, to correct situations which may cause congestion and delay, and to know where each serial can be reached in order to issue new orders if necessary.
- (2) Colored pencils, crayons, ink, or adhesive tape may be used to indicate various schedules and the relative priority of movements or to plot movements in progress. For example, the head and tail schedule may be outlined by black lines, progress of each serial may be filled in with green, and failure to adhere to the schedule may be shown in red.
- (3) Figure 3.22 shows the plotted progress of serials scheduled in figure 3.21. Note the changes and adjustments in schedules that had to be made. This is what happened:
 - (a) *Serial A.* Went through as scheduled.
 - (b) *Serial B.* Change in orders required that serial B continue on to Dundalk. It continued on schedule, and the head of the column arrived at its new destination at noon.
 - (c) *Lateral movement.* Because of a change of orders for serial B, arrangements had to be made to hold the lateral movement at McLean. It made its noon halt and crossed the route 3 hours behind its original schedule, not clearing until 1830.

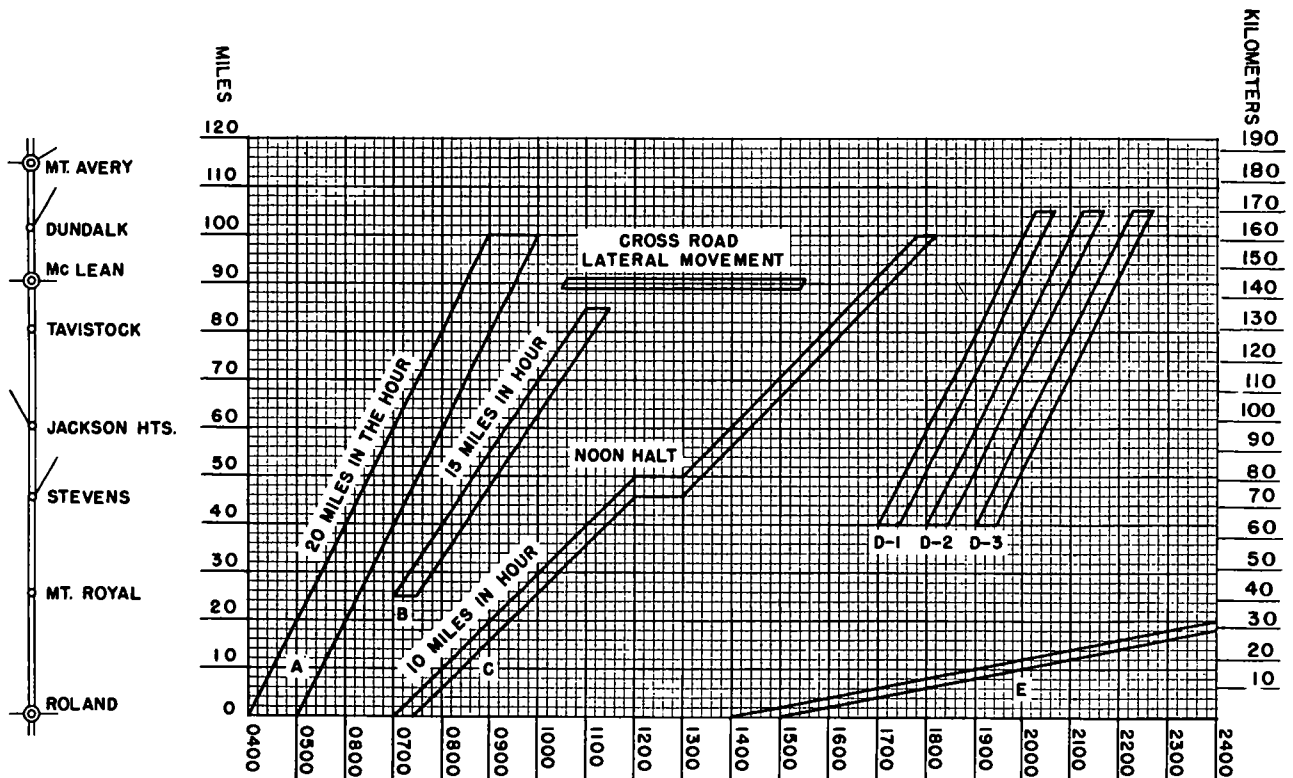


Figure 3.21. Road-movement graph.

- (d) *Serial C.* At 1200 it became obvious that if serial C continued on schedule it would conflict with the delayed lateral movement at about 1730. Serial C also had lost priority, because of the arrival of serial B at Dundalk with critically needed supplies. Therefore, serial C was halted for 2 hours (1200–1400). It continued at a slower rate of march until 1700, when it was halted again to let serial D pass.
- (e) *Serial D (D-1, D-2, D-3).* All elements went through on schedule.

3.21 Traffic Density

a. Traffic density is the average number of vehicles occupying a specified length of roadway at a given instant or the number of vehicles passing a given point at constant speed in a specified period of time. Traffic density is expressed in vehicles per mile or kilometer and can be determined by the formulas shown below.

b. Any traffic density desired for dispersion or for maintaining the maximum capacity of a route may be arrived at by selecting an appropriate

intervehicular gap and using the following formulas:

$$\frac{1 \text{ mile in yards}}{\text{Desired intervehicular gap in yards} + \text{avg length of 1 veh}} = \text{vehicles per mile}$$

$$\frac{1 \text{ kilometer in meters}}{\text{Desired intervehicular gap in meters} + \text{avg length of 1 veh}} = \text{vehicles per kilometer}$$

EXAMPLE: If vehicles are dispersed every 100 yards (91.4 meters), density is:

$$\frac{1,760}{100 + 10} = 16 \text{ vehicles per mile}$$

$$\frac{1,000}{91.4 + 9} = 10 \text{ vehicles per kilometer}$$

c. When the speed and speedometer multiplier are known, traffic density may be determined by using the following formulas:

$$\frac{1 \text{ mile in yards}}{(\text{Speed in mph} \times \text{speedometer multiplier}) + \text{avg length of 1 veh}} = \text{veh per mile}$$

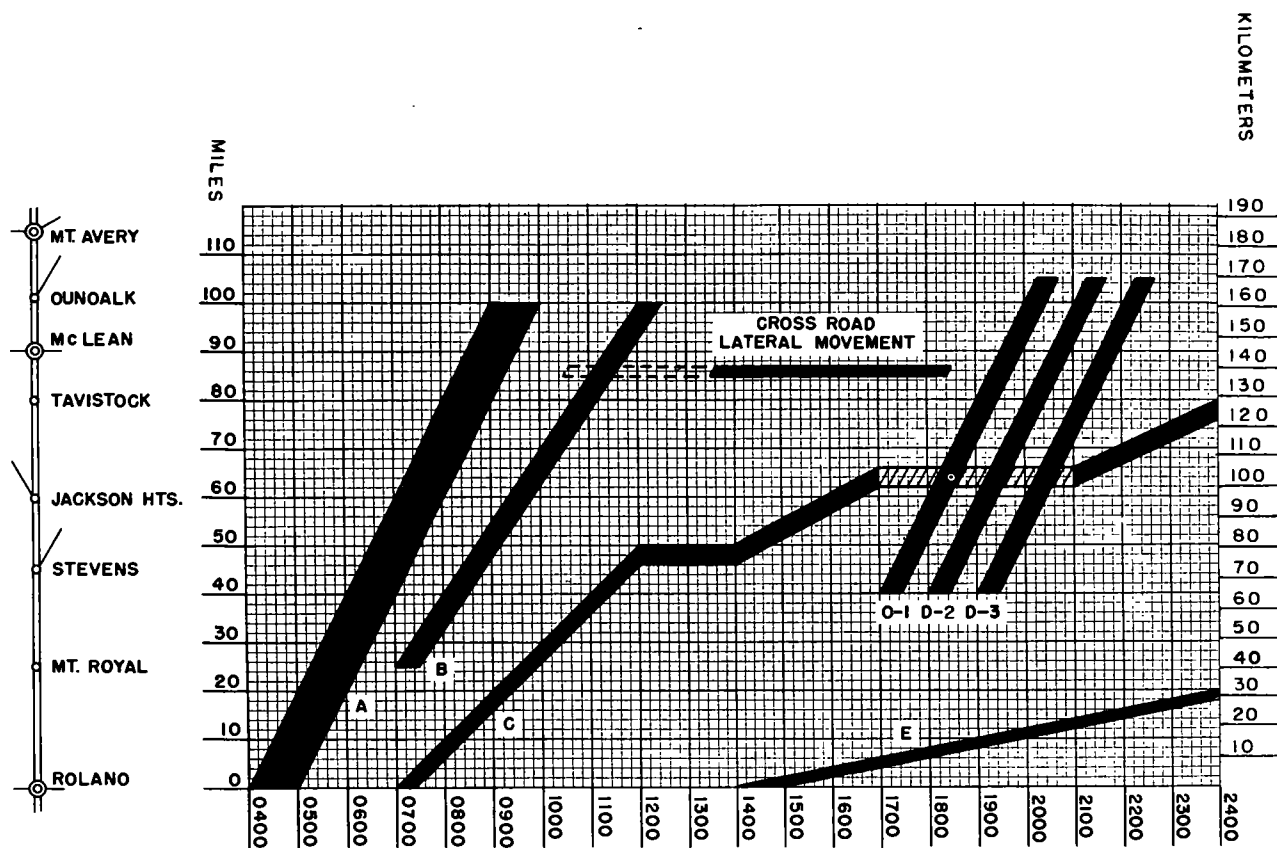


Figure 3.22. Deviations from schedules.

$$\frac{1 \text{ kilometer in meters}}{(\text{Speed in kmph} \times \text{speedometer multiplier}) + \text{avg length of 1 veh}} = \frac{\text{veh}}{\text{per kilometer}}$$

EXAMPLE: If the speed of a column is 20 miles per hour (32.19 kilometers per hour) and speedometer multipliers of 2 for miles and 1.2 for kilometers are used, traffic density is:

$$\frac{1,760}{(20 \times 2) + 10} = 35 \text{ vehicles per mile}$$

$$\frac{1,000}{(32.19 \times 1.2) + 9} = 21 \text{ vehicles per kilometer}$$

d. At a constant speed, traffic density can also be determined by counting the number of vehicles passing a given point in a period of time. Use the following formulas:

$$\frac{\text{Vehicles per hour passing point}}{\text{Speed in miles per hour}} = \text{vehicles per mile}$$

$$\frac{\text{Vehicles per hour passing point}}{\text{Speed in kilometers per hour}} = \text{vehicles per kilometer}$$

EXAMPLE: If 500 vehicles pass a given point in ½ hour at 20 miles per hour (32.19 kilometers per hour), traffic density is determined as follows:

$$500 \text{ vehicles per } \frac{1}{2} \text{ hour} = 1,000 \text{ vehicles per hour}$$

$$\frac{1,000}{20} = 50 \text{ vehicles per mile}$$

$$\frac{1,000}{32.19} = 31 \text{ vehicles per kilometer}$$

3.22 Road-Movement Table

a. A road-movement table provides a convenient means of transmitting to subordinates information about schedules and other essential details. This is particularly so if the inclusion of such details in the body of the operation order

(SECURITY CLASSIFICATION)

Annex _____ to _____ (Formation/Unit)

Operation Order No. _____

Dated _____

These routes and points are here described by grid references, codewords, etc., and if necessary, numbered or lettered for ease of reference in the columns below.

Maps _____

1. Average speed
2. Traffic density
3. Halts

4. Routes (between start points and release points may be indicated by code—red, green, etc.)

5. Critical points¹
 - a. Start points
 - b. Release points
 - c. Other critical points

6. Main routes to start points
7. Main routes from release points

Serial ² (a)	Date (b)	Unit/Formation (c)	Number of vehicles (d)	Load class of heaviest vehicle (e)	From (f)	To (g)	Route (h)	Route to start point (i)	Critical points ¹			Route from release point (m)	Remarks ³ (n)
									Location (j)	Due (hr) (k)	Clear (hr) (l)		
1	1 Sep	1st BG, 86th----- Inf (Motor elements, close column).	142	21	Alfa	Bravo	Red	71	RJ 620 (SP) CR 212 CR 427 CR 442 (RP)	0001 0021 0041 0118	0019 0039 0059 0136	11	None

¹ Critical points are selected points along the route used for reference in giving instruction. These points include start point, release point, and other points along the route where interference with the movement may occur or where timing is critical.

² A movement serial is defined as an element or group of elements within a series and in this table has a numerical designation for convenience in planning, scheduling, or control of movement.

³ Information which is common to two or more serials will be given in the beginning of the table, items 1-7.

SAMPLE ROAD MOVEMENT TABLE

would tend to complicate it or make it unduly long. Tables frequently require a wider distribution than normal operation orders because copies are issued to convoy operating personnel, traffic regulating personnel, and traffic control posts. For security reasons, it may not be desirable to include dates or locations. Security classification is given in accordance with contents of the table; it is not necessarily the same as that of the operation order. If the table is issued by itself and not as an annex to a more detailed operation or administrative order, it must be signed and/or authenticated in the same manner as other orders.

b. The beginning of the table includes general information common to two or more serials, e.g., security classification, maps, average speed, traffic density, halts, main routes to the start and release points, and information about other critical points. Information concerning the routes and critical points is normally described by grid references, codewords, etc., and, if necessary, may be numbered or lettered for ease of reference to the columns in the table. The remainder of the table includes information concerning each individual serial and is arranged in tabular form. A sample road-movement table is shown below.

3.23 Combined Order, Log, and Strip Map (fig. 3.23)

In some situations it may be advantageous to combine on one sheet an operation order, a log of road movement, and a strip map, as shown in figure 3.23.

3.24 Convoy Commander's Checklist

If each item listed below is checked and acted upon carefully by the convoy commander *before* departure time, the chances of neglecting some important arrangement will be minimized.

1. Where is start point? Release point?
2. What route is to be used?
3. Has reconnaissance been made and condition of route determined?
4. Can bridges and defiles safely accommodate all loaded and/or tracked vehicles?
5. Are critical points known and listed on strip maps?
6. Has the size of serials been determined?
7. Has the size of march units been determined?
8. What will be the rate of march?

9. What is the vehicle interval on open road?

.....
In built-up areas? At halt?

10. Type of column
11. Has provision been made for refueling, if required?
12. Has a suitable bivouac site been selected, if required?
13. Have suitable rest and mess halt areas been selected, if required?
14. Is road-movement table needed?
- Prepared?
- Submitted?
15. Have convoy clearances been obtained?
- What number? What date?
16. Is escort required and has it been requested?
17. Are spare trucks available for emergencies?
18. Are vehicles fully serviced, clean, and ready for loading?
19. Is load proper, neat, and balanced?
20. Are drivers properly briefed?
- By whom, when? Strip maps furnished?
21. Is convoy marked front and rear of each march unit?
22. Are guides in place? Have arrangements been made to post guides?
23. Are blackout lights functioning?
24. Are maintenance services alerted?
25. Is maintenance truck in rear?
- Are medics in rear? Plan for casualties?
26. Are all interested parties advised of ETA?
27. Is officer at rear of convoy ready to take necessary corrective action, such as changing loads, investigating accidents and unusual incidents? Who is trail officer?
28. Is there an entrucking plan?
- Who is responsible?
29. Is there a detrucking plan?
- Who is responsible?
30. Has a plan been made for feeding personnel?
31. Have times been established for entrucking or loading?
32. Has time been established for formation of convoy?
33. Have times been established for detrucking

or unloading?-----

34. Has time been established for releasing trucks?-----
Who is responsible?-----

35. Is there a carefully conceived plan known to all personnel in the convoy that it can be used in case of attack?-----
36. Is a written operation order on hand, if required?-----

OpnO I

Map Strip map.

CI No. 5-080109

1. (a) No change.
(b) 400TT bn displ vic Melun.
2. 2420TTCo displ vic Melun & Mov cl I and V sup FWD.
3. (a) See log of march.
(b) 1st plat loaded w/ cl I.
(c) 2d plat loaded w/ cl L.
(d) 3d plat loaded w/ cl V.
(e) Max speed 35mph (56.3 Km/h).
(f) SP-100724 Mar CR 108.
4. (a) SOP.
(b) Medics atchd trail.
5. (a) SOP.
(b) CP head 2d plat

Comander

Acknowledgment: Whitt, Capt.

Note: On strip map, Kilometers are shown in parentheses.

2420 Trans Co							
Sees							
091115 Mar 1962							
Log of road movement							
Highway clearance No. 5-080109 Mar							
Route	Check point	Distance from last check point		Distance from starting point		Time of arrival	Remarks
		MI	KM	MI	KM		
	Sees (SP)	0		0		0724	DEPART.
	CR 108						
N-138	Q203	12	19.3	12	19.3	0800	2 hr loading.
	Alencon	1	1.61	13	20.9	1003	
N-155	Nogent	38	61.1	51	82.0	1157	1 hr lunch halt.
N-23	Chartres	33	53.1	84	135.1	1436	
N-188	Ablis	17	27.4	101	162.5	1527	
N-191	Etampes	18	29.0	119	191.5	1621	
N-837	Fontainebleau	29	46.6	148	238.1	1748	
	Melun (RP)	11	17.7	159	255.8	1821	Contact adv detail.
Rate of march: 20 mi/h. (32.2 Km/h).							

Rate of march: 20 mi/h. (32.2 Km/h).

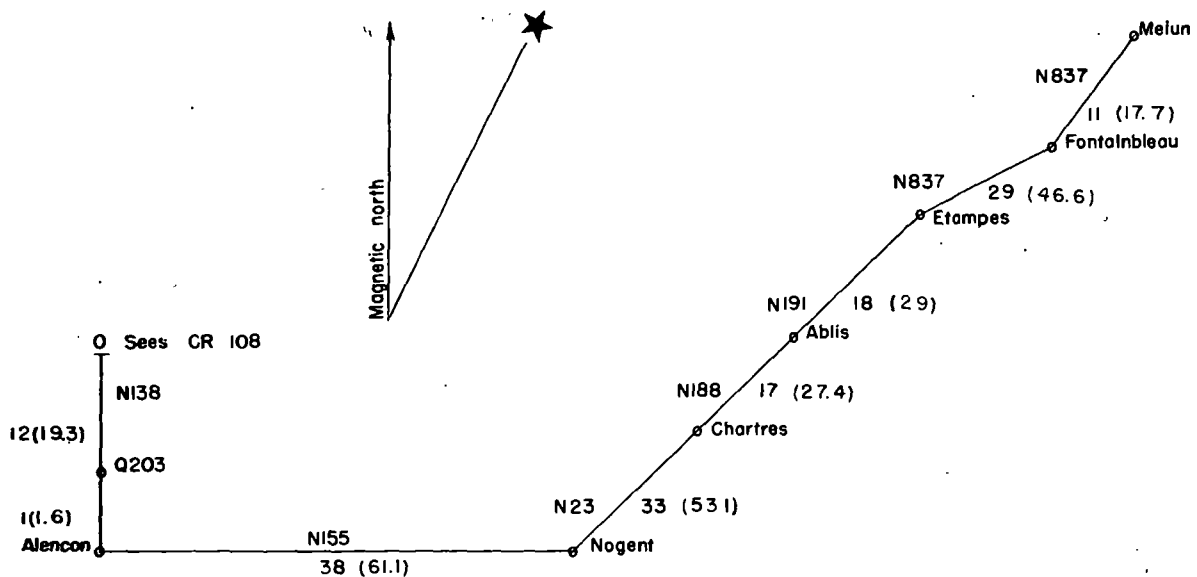


Figure 3.23. Sample combined order, log, and strip map.

37. Will a log of road movement be required at end of trip?-----
Are the necessary forms on hand?-----
38. Has weather forecast been obtained?-----
39. Do all personnel have proper clothing and equipment?-----
40. Is there a communications plan?-----

3.25 Convoy Commander's Report

The convoy commander prepares this report after a move has been completed and normally submits it to his immediate superior officer. The sample report below may be used as a guide. However, the report may be submitted in the form of a strip map, with an appropriate legend attached.

FORWARD LOAD

420 Trans Bn (Trk)	4401 Trans Co (Lt Trk)
7A26FEB23	Twelve 2½-ton
(Convoy No.)	(No. and type of task vehicles)
	16 Feb 62
	(Date)

TIME:

Convoy departed SP.....	0621
Convoy departed 1st load- ing point.....	0800
Convoy arrived at 1st load- ing point.....	0630
Time at 1st loading point.....	1 hr. 30 min.
Arrived at HRP.....	1200
Departed HRP.....	1205
Departed 1st unloading point	1245
Arrived at 1st unloading point.....	1212
Time at 1st unloading point.....	33 min.

SUPPLIES AND PERSONNEL:

Cargo (short tons).....	50.2
Class of supplies.....	I
Personnel.....	O

DISTANCE:*

Speedometer reading of lead vehicle (1st loading pt)....	21,324
Speedometer reading of lead vehicle (SP).....	21,322
Total forward (no load).....	2
Speedometer reading of lead vehicle (1st unloading pt)...	21,381
Total forward (loaded).....	57

REMARKS:

SP—Company area, RJ 124/167
Weak bridge 6.4 miles east of 1st loading point. Road
generally in poor condition between SP and 1st unload-
ing point.

RETURN LOAD

TIME:

Departed 2d loading point...	1300
Arrived at 2d loading point (same as 1st unloading pt).....	1245

Time at 2d loading point.....	15 min.
Departed 2d unloading point.....	1415
Arrived at 2d unloading point.....	1400
Time at 2d unloading point.....	15 min.

SUPPLIES AND PERSONNEL:

Cargo (short tons).....	10
Class of supplies.....	II & IV
Personnel.....	120

DISTANCE:*

Speedometer reading of lead vehicle (2d unloading pt)...	21,396
Speedometer reading of lead vehicle (2d loading pt)....	21,381
Total return (loaded).....	15
Speedometer reading of lead vehicle (SP).....	21,436
Total return (no load).....	40

REMARKS:

Road in excellent condition between 2d loading point
and SP

ROUND-TRIP DATA

TIME:

Time returned to SP.....	1654
Total round-trip time.....	10 hr. 33 min.
Total travel time (including halts).....	8 hr.
Total loading time.....	1 hr. 45 min.
Total unloading time.....	48 min.

SUPPLIES AND PERSONNEL:

Cargo (short tons of C1 I)...	50.2
(short tons of C1 II & IV).....	10
Personnel.....	120

DISTANCE:*

Total distance (loaded).....	72
Total distance (unloaded)...	42
Total round-trip distance....	114

REMARKS:

* Distances shown are in miles (multiply by 1.609 to
convert to kilometers). Average rate of march = 14.2
mih = 22.9 kmih. Ton-miles: Forward—2,861; Re-
turn—150. Passenger-miles: Forward—0; Return—
1,800.

s/Thomas A. Young
(Signature—convoy commander)

2d Lt. 4401 Trans Co (Lt Trk)
(Rank or grade and organization)

3.26 Convoy Clearance

A convoy clearance request is usually required from a unit or organization that is planning a move by convoy. The information required varies according to local SOP's and regulations. The sample outline below shows the information usually required by any authority that issues road

clearances. When available, DD Form 1265 should be used. In a field army, the traffic headquarters normally determines routes to be used and issues road clearances.

From: S3 1429 TTBn

Phone: Barkersville 1429

Time and date: 261530 Oct 61

Authority for movement: MO 341, HQ TALOG, dated 19 Oct 61

Convoy No: 12B

Unit name or serial No: 4406 T Car Co

Personnel: 4 Off 98 EM

Total No. of vehicles: 51 trks, 31 tlr

Type and number of vehicles: 38 1/4-ton trks, 25 1/4-ton tlr,
3 1/4-ton trk, 4 1 1/2-ton trks, 8
2 1/2-ton trks, 6 1-ton tlr

No. of serials: 3

Vehicles by type and number in serials (do not show control, mess, or maintenance vehicles):

(1) 2 2 1/2-ton trks, 12 1/4-ton trks, 1 1/2-ton trk, 2 1-ton tlr, 8 1/4-ton tlr

(2) Same as 1st serial

(3) Same as 1st serial

Intervehicular gap: 60 55
(yards) (meters)

Average length of vehicles and/or combinations:

10 9
(yards) (meters)

Gap between serials: Distance 2935 2684
(yards) (meters)

Time 5
(min.)

Length of serials: Distance 990 905 Time 1.69
(yards) (meters) (min.)

Total length of convoy: Distance 8840 8083
(yards) (meters)

Time 15
(min.)

Cargo and tonnage¹: 36 tons of baggage and organizational equipment.

Outsized or overweight loads: None

SP: Barkersville

Scheduled time and date of departure: 290700 Oct 61

Proposed route: Barkersville, RJ 261, Kennedy, Kleburg, Exeter

Destination: Exeter

Estimated time and date of arrival: 291900 Oct 61

Rate of march: 20 32
(mih) (kmih)

Scheduled halts: 15 min. RJ 261; 1 hr Kennedy; 15 min. Kleburg

Scheduled bivouacs: Arrive: NA Depart: NA

POL points (determined by staff transportation officer): NA

Highway regulation (determined by staff transportation officer): Advised Sgt Harris in office of staff transportation officer at 261015 Oct 61. Clearance granted by Lt Brown, office of staff transportation officer at 261230 Oct 61.

¹ If cargo includes explosives, include data required by local SOP and/or regulations.

Critical points:	Name of Point	ETA	ETD
	RJ 261	0900	0915
	Kennedy	1215	1315
	Kleburg	1615	1630
	Exeter	1900	

Remarks²: 1. POL points not needed. Convoy will be refueled by tankers during halt at Kennedy.
2. Unit commander will insure strict compliance with all SOP's and with all highway regulation and control procedures issued by competent authority.

s/George A. Harkins
(Signature)

GEORGE A. HARKINS

Name (printed or typed)

Capt, S3 1429 TTBn

Grade, title, and organization

3.27 Traffic Headquarters

a. *Mission.* The traffic headquarters regulates traffic that is moving into and out of the corps and division areas. It coordinates routes and schedules in order to obtain schedules to pass convoys into the army rear. Lateral traffic is coordinated by the traffic headquarters involved. The higher headquarters settles disputes in any schedule conflict.

b. *Functions.* The traffic headquarters coordinates the movement of all units assigned or attached; maintains liaison with traffic headquarters of higher and lower commands; prepares the traffic circulation plan and the motor transport portion of other plans and orders issued by the headquarters; and prepares and maintains up-to-date road-movement tables to support army, corps, or division emergency plans.

c. *Organization.* The transportation officer at army headquarters has operational control of the Army traffic headquarters. Transportation officers at corps and division levels have operational control over their respective traffic headquarters, and each is under the supervision of the appropriate higher headquarters. The traffic headquarters is organized by the staff transportation officers at all three levels and comes under the general staff supervision of the G-4.

3.28 Highway Schedule Request

This request is submitted by a unit desiring to use certain parts of the highway at specified times. Clearances are normally issued by post transportation officers, and highway regulation is not required. A sample request that shows the information usually required is given below.

² Remarks should include statement of nature and quantity of all logistical support required.

1. FOR (UNIT) 4401st Trans Company (Light Truck)
2. ORIGIN Fort Eustis, Va. DESTINATION Camp A. P. Hill, Va.
3. DESTINATION INSTALLATION Moss Neck area
4. VEHICLES BY TYPE

Wheeled				Tracked	Total
Smaller than 2½-ton	2½-ton	5-ton	Larger than 5-ton		
5	45	None	1	None	51

REMARKS: Vehicle larger than 5-ton is a truck, 6-ton, 6 × 6, wrecker

5. LIMITATIONS (SPECIAL SCHEDULING): (a) LGTH NA (b) WIDTH NA (c) HGT NA (d) WGT NA
6. (a) No. SERIALS 3 (b) INTERVAL 5 min. (c) No. MARCH UNITS 9 (d) INTERVAL 2 min (within serials)
 (e) TIME LENGTH 28 min. (f) RATE OF MARCH 20 mih (g) TYPE CARGO None (training mission)
 (h) TONS None
7. CONVOY COMMANDER 1st Lt James E. Brown
8. ROUTE AND SCHEDULE

(a) Critical points	(b) Arrive	(c) Clear	(d) Route	(e) MP escort required	(f) Remarks
Main Gate, Ft Eustis, Va.	210600 May 62	210628 May 62	Rts 60, 238, 168, North	Yes	
RJ Routes 168 and 30	210700 May 62	210728 May 62	Rts 30 and 33, East	No	
RJ Routes 33 and 17	210800 May 62	210828 May 62	Rt 17, North	No	

9. PERSONNEL, IF LOGISTICAL SUPPORT REQUIRED: (a) OFF None (b) EM None (c) OTHER None
10. SUPPORT REQUIRED None

REQUESTED BY Maj John P. Doe
 DATE 16 May 1962 TIME 0800
 MOVEMENT No. 23-2-62
 ORGANIZATION 23d Transportation Group (Truck)
 RECEIVED BY Lt Brown (Transportation Office)

3.29 Vehicle Loading

a. *Responsibility.* The driver is responsible for his vehicle being loaded properly.

b. *Rules for Loading* (fig. 3.24).

- (1) Place heavy supplies at the bottom of the load and distribute evenly over cargo floor.
- (2) Place the load so it won't shift; distribute the weight equally.
- (3) Do not distribute load loosely or build it up too high. High, loosely distributed loads cause swaying, make the vehicle difficult to handle, and increase the danger of losing the cargo or overturning the vehicle.

- (4) If the truck has an open body, put a tarpaulin, when practicable, over the cargo to protect it against sun, dust, or rain.
- (5) If possible, place barrels and drums on their sides—parallel with the length of the truck—brace, and pyramid them. If the possibility of leakage does not permit this placement, set the drums upright. This latter arrangement does not permit the loading of as many drums in the same space.
- (6) Combine boxed, crated, and packaged cargo, as far as possible, with like items or items of combining shapes.

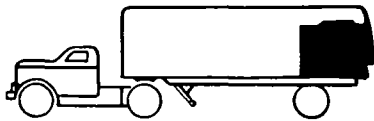


WRONG



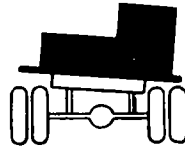
RIGHT

The right vehicle for the right job.



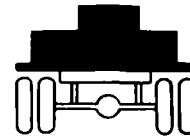
WRONG

This overloads trailer rear wheels, brakes won't brake properly, rubber scuffs away. Distribute the load over the full trailer floor.



WRONG

This overloads one spring and set of tires. Brakes lock on the light side, cause skids.



RIGHT

Nothing overloaded, frame won't twist and loosen cross-member rivets.



WRONG



RIGHT

This overloads and shortens tire life, bends the truck rear-axle housing. Applying the trailer brakes may lock the wheels, cause flat spots and skidding.

Figure 3.24. How to load a truck.

- (7) Load sacked cargo separately, or so as not to risk its being punctured by odd-shaped or sharp-edged items; stack it in overlapping layers to prevent shifting.

3.30 Vehicle Capacities and Capabilities

The figures below should be used for planning

a. Local and Line Hauls.

purposes only. They are based upon experience gained in the field and are averages for the various makes and models of the equipment listed. Weather, roads, terrain, and tactical situation must also be considered.

Type of equipment	Avg load per veh trip	Loading and unloading time (hr) per round trip	Local hauls ¹			Line hauls ²			
			Avg distance forward		Round trips per veh per day	Distance in the hr		Avg daily distance capability	
			Mi	Km		Mi	Km	Mi	Km
Truck, carg :									
2½T, 6 × 6.....	4 tons	2½	15	24	4	15	24	125	201
5T, 6 × 6.....	6 tons	2½	15	24	4	15	24	125	201
Semitrailer									
12T, S&P.....	12 tons	2½	15	24	4	15	24	125	201
Gas tank, 12T, 4 W.....	5,000 gal.	2½	15	24	4	15	24	125	201
Refrg, 7½T, 2W.....	6 tons	2½	15	24	4	15	24	125	201
Low-bed wrecker, 12T, 4W.....	1 missile	2½	15	24	4	15	24	125	201
Tank trans, 50T.....	50 tons	2½	15	24	4	11	18	90	145

¹ Includes port and beach clearance.

² Figures are for long-range planning. Multiply by 4/3 or 1.33 for short-range planning quantities.

b. Payload Capacities.

Type of equipment	Maximum cargo loads		Men w/indiv equipment ^a
	Off road	Highway	
Truck, cargo:			
2½T, 6 × 6.....	2½ tons	5 tons	16
5T, 6 × 6.....	5 tons	10 tons	18
Semitrailer:			
12T, S&P.....	12 tons ^b	18 tons	50 ^c
Gas tank, 12T, 4W....	3,000 gal.	5,000 gal.	NA
Refrg, 7½T, 2W.....	6 tons ^b	7½ tons	NA
Low-bed wrecker, 12T, 4W.....	1 missile	1 missile	NA
Tank trans, 50T.....	40 tons ^b	50 tons	NA

^a Does not include driver. For distance greater than 75 miles, the figure should be reduced.

^b Not generally used for this type operation.

^c Recommended for emergency use only.

c. Vehicle Availability. In advance highway transport planning, availability means the average number, or percent, of vehicles in a unit that

d. Capabilities of Truck Companies.

can be operated continuously for 20 hours during each 24-hour period. The table below gives planned availability figures. Availability figures are greater than those shown in the table for a longer daily operation or for a specific task, such as a short one-lift haul. The planning figure must not be confused with actual availability, which is obtained from vehicle records and reports.

Unit	Task vehicles assigned	Vehicle availability		
		Advance planning ¹	Target ² (24-hour/day)	Spot tasks
Trans light trk co	60	45	50	57
Trans med trk co	60	45	50	57
Trans hvy trk co	24	18	20	23
Trk pools	Any number	75%	83%	95%

¹ Also used when involved in particularly rigorous operations remote from adequate maintenance, or when actual operating conditions cannot be determined.

² With well trained and disciplined personnel, good operating conditions, and adequate maintenance support.

Type of equipment	Type haul				
	Local ^a		Line ^b		
	Short tons daily	Metric tons daily	Short ton-miles daily	Metric ton-kilometers daily	Short ton-kilometers daily
Truck, cargo:					
2½T, 6 × 6.....	720	653	22,500	32,843	36,180
5T, 6 × 6.....	1,080	980	33,750	49,264	54,270
Semitrailer:					
12T, S&P.....	2,160	1,960	67,500	98,528	108,540
Gas tank, 12T, 4W.....	900,000 gal. ^c	3,406,500	84,375 ^d	123,161	135,000
Refrg, 7½T, 2W.....	1,080	980	33,750	49,264	54,270
Low-bed wrecker, 12T, 4W.....	40 large missiles ^c	-----	20 large missiles ^c	-----	-----
Tank trans, 50T.....	3,600	3,266	81,000	118,234	130,500

^a Based on vehicle availability × avg load per veh trip × round trips per veh per day.

^b Based on vehicle availability × avg load per veh trip × avg daily distance capability.

^c Tonnage figures not applicable.

^d Based on liquid POL weighing 6 lb (2.7216 kg) per gal.

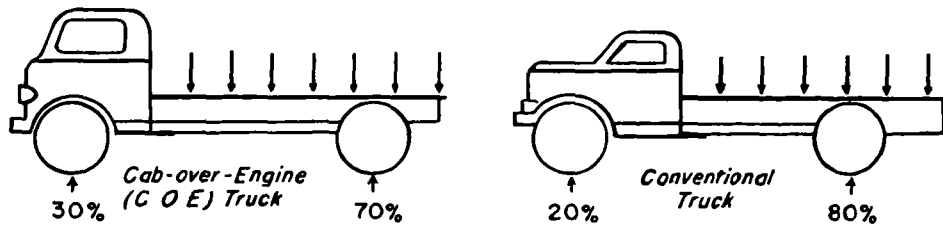
3.31 Vehicle Unitized-Load Capacities

Load	Vehicle			
	2½T cargo truck ^a		10T stake and platform trailer	
	Sides in place, crane-loaded	Sides removed, fork-lift-loaded	Sides in place, crane-loaded	Sides removed, fork-lift-loaded
Cargo net.....	3	Not recommended	6	Not recommended
Cargo transporter, type 2.....	1 lengthwise	1 lengthwise	3 lengthwise	4 crosswise ^b
Stevedore pallet.....	2 crosswise	4 lengthwise	6 crosswise	8 lengthwise: 2 rows of 4 ^c
Unitized pallet.....	3 crosswise	5: 4 lengthwise; 1 crosswise.	7 crosswise	10 lengthwise: 2 rows of 5 ^c
Warehouse 4 × 4 pallet.....	3	3	6	12: 2 rows of 6

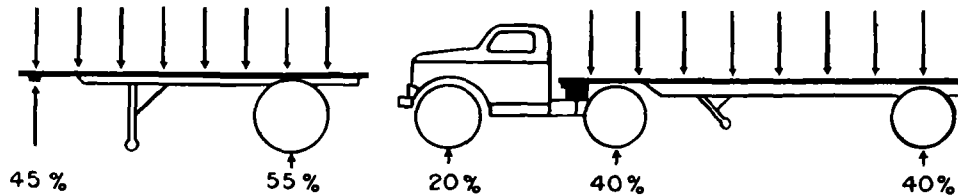
^a Some 2½-ton, 6 × 6, cargo trucks have fender wells which project into the cargo space. In such cases, a level platform for the storage of a unitized cargo can be obtained by fitting a frame of 2 by 4 or 4 by 4 timbers flat in the cargo bed between the fender wells.

^b May be loaded by crane.

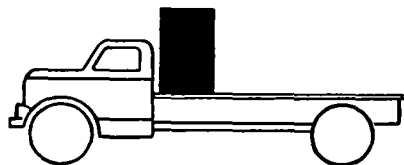
^c Increase by one for 12-ton stake and platform trailer.



Tires, axles, frame, etc., are designed to carry a load distributed as above.

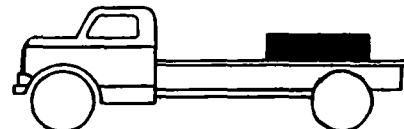


Distribute trailer loads equally between the rear tires and the fifth wheel. This transfers the load to the tractor.



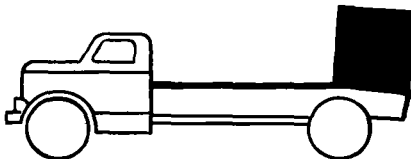
WRONG

This will bend the frame, overload front tires, making steering harder.



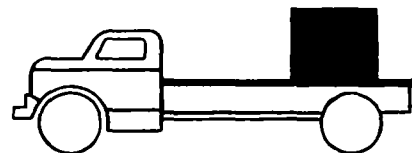
RIGHT

Place heavy part of load near rear axle for proper tire loading and to keep frame from bending.



WRONG

This kind of weight distribution bends the frame, overloads rear tires, and makes steering almost impossible.



RIGHT

Set a concentrated load just ahead of the rear axle with, if possible, the longest side on the floor

Figure 3.24.—Continued.

3.32 Motor Vehicle Shipments of Hazardous Cargo

a. The following measures must be enforced to prevent fire:

- (1) Smoking must be prohibited within 50 feet (15 meters) of a vehicle loaded with explosives or flammable liquids. Open flames, such as those produced by striking

matches and using cigarette lighters, torches, etc., must be prohibited within 100 feet (30 meters) of any motor vehicle loaded with explosives or gasoline.

- (2) Two fire extinguishers, properly filled, should be provided, one inside the cab and one outside, on the driver's side.
- (3) All personnel should be instructed in the proper use of fire extinguishers and,

where practicable, the instruction should be supplemented by demonstrations.

- (4) If a truck catches on fire, all trucks should be moved away from the vicinity of the fire and all traffic stopped. Every effort should be made to warn inhabitants living in the vicinity of the danger.
- (5) When loading or unloading trucks, explosives must not be placed in the vicinity of the exhaust.
- (6) Ignition and lighting systems should be properly insulated and inspected frequently to insure that danger from short circuits is eliminated.
- (7) Every effort should be made to prevent leaks in gasoline tanks, fuel lines, and carburetors. When a leak is discovered, the truck should be unloaded and moved to a safe distance before repairs are made.
- (8) Oil and grease thrown from parts should not be allowed to accumulate on the truck body, engine, or other places where a fire hazard would result.

b. Motor vehicles transporting explosives or gasoline must not be driven past fires of any kind until it has been ascertained that the fire can be bypassed safely.

c. Advance reconnaissance and contact with civilian traffic officials are essential. Routes selected, if possible, should avoid heavy traffic and large cities.

d. Loitering should not be permitted in the vicinity of a vehicle in convoy.

e. When a truck breaks down, it should be moved off the road or as far to the side as possible and, pending the arrival of an empty truck or repair party, left in charge of a guard.

f. Fuzes and detonating devices must not be carried in the same truck with other explosives (fixed and semifixed ammunition are exceptions).

g. The interior of the truck body should be lined so that every portion of the lining with which a container may come in contact is of wood or other nonsparking material.

h. Loads should be braced and stayed to prevent shifting.

i. A truck loaded with explosives or gasoline must never be towed or pushed except when a

disabled truck must be moved to the side of the road.

j. Hourly halts should be made to inspect loads and vehicles.

k. Motor vehicles transporting explosives on public roads or highways must be marked with placards bearing the word *EXPLOSIVES* in letters at least 8 inches (21 cm) high. The placards must be prominently located on each side, and on the front and rear of the truck.

l. A motor vehicle transporting explosives or gasoline must not be left unattended upon any public street or highway.

m. The vehicle motor must not be running when explosives or gasoline are being loaded or unloaded.

n. When a truck has an open body, a tarpaulin must be used to protect the cargo from rain or the direct rays of the sun.

o. The entire cargo of explosives or ammunition must be transported within the body of the truck. The truck tailboard or tailgate must be closed and secured.

p. Cargo such as dynamite and certain other explosives must be protected from intense cold, which can cause the explosive to deteriorate or become dangerous. Freezing characteristics of the cargo must be determined before transporting in temperatures below 32° F. If necessary, insulated vans must be used.

3.33 Vehicle Missile-Carrying Capabilities

The missile-carrying capabilities of certain types of vehicles normally found in highway units are given in *a* and *b* below. In each case, either weight or volume is the limiting factor. To achieve the loads indicated, it may be necessary to raise or remove the tops of some trucks and trailers. The loads given do not exceed width dimensions of the vehicles except in some cases for low-bed and flat-bed trailers. Subparagraph *c* shows some of the special equipment used to transport one complete round or the major components thereof. In the tables, column A indicates the number of packaged missiles or indicated component one vehicle can transport. Column B shows the number of vehicles required to transport one packaged missile or indicated component.

a. Transportation Light Truck Company (TOE 55-17).

Vehicles	Niko-Ajax		Niko-Hercules		Little John		Lacrosse		Sergeant		Honest John (M31)		Corporal		Pershing		Redstone		SS-10		SS-11		Mauler		Hawk	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Trailer:																										
Cargo, ¼T, 2W, M100-----																			2	1	2	1				
Cargo, 1T, 2W-----																			6	1	8	1	14	1		
Cargo, 1½T, 2W, M104-----					1	1													16	1	14	1	21	1		
Flat-bed, guided missile, M261, 3, 245 lb-----		2			1	1													17	1	20	1	23	1	1	1
Truck:																										
Cargo, 2½T, 6 × 6, M35-----					2	1		2											26	1	28	1	35	1		
Cargo, 2½T, 6 × 6, M135-----					2	1		2											20	1	20	1	35	1		
Cargo, 5T, 6 × 6, M54-----				3	2	1	1	1		2	1	1				4			30	1	32	1	74	1	3	1
Cargo, 5T, 6 × 6, M551-----	1	1		3	4	1	1	1		2	1	1				3			48	1	48	1	71	1	3	1

b. Transportation Medium Truck Company (TOE 55-18).

Semitrailer:																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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c. Special Transport Equipment.²

Trailer, rocket, XM449.....					1	1																			
Truck, 2 1/2T, 6 x 6, M45E3, with launcher, XM398E1.....							1	1																	
Semitrailer (Sergeant warhead and forebody).....									1	1															
Semitrailer (Sergeant motor), guidance, and fin.....									1	1															
Truck-mounted launcher, M289 (Honest John rocket).....											1	1													

See footnotes at end of paragraph.

Vehicles	Nike-Ajax		Nike-Hercules		Little John		Lacrosse		Sergeant		Honest John (M31)		Corporal		Pershing		Redstone		SS-10		SS-11		Mauler		Hawk	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Truck-mounted launcher, M386 (Honest John rocket).....											1	1														
Erector, self-propelled, M2 (Corporal).....													1	1												
Erector-launcher, GM transportable (Pershing).....															1	1										
Redstone missile transporter (warhead unit) ³																	1	1								
Redstone missile transporter (thrust unit) ³																	1	1								
Redstone missile transporter (aft unit) ³																	1	1								

¹ Requires special authorization. Normally assigned to Ordnance special ammunition companies.

² Equipment shown does not include all ground servicing equipment.

³ In addition to the three transporter vans, the Redstone missile (see par. 7.5) requires additional vehicles. Any suitable combination of the vehicles shown under a and b above will suffice. Vehicles smaller than 2½-ton trucks are not recommended.

3.34 Computing Truck Unit Requirements

a. *One-Lift Hauls*. To determine the number of truck companies required to move a given number of tons in one lift, use the following formula:

$$\frac{\text{Tons to be lifted}}{\text{Tons per veh} \times \text{veh availability per co}} = \text{truck companies required}$$

EXAMPLE: Determine number of light truck companies required to move 2,700 tons in 1 lift.

Assuming: 4 = tons per 2½-ton, 6 × 6 truck

45 = vehicle availability per company

Substitute in formula:

$$\frac{2,700}{4 \times 45} = 15 \text{ companies}$$

b. *Sustained Forward Hauls (Continuous Operation Using Relays)*. In sustained forward hauls, trucks return for additional loads, and it is necessary to consider turnaround time and the daily operating time. To determine the number of truck companies required to move a given forward tonnage daily, use the formula below.

Daily forward tonnage

$$\frac{\times \text{turnaround time in hours}}{\text{Tons per veh} \times \text{veh available per co} \times \text{operating time in hours (daily)}} = \text{truck companies required}$$

EXAMPLE: Determine the number of medium truck companies equipped with semitrailers, 12-ton, stake and platform, required to move an average tonnage of 4,800 short tons daily for a round-trip distance of 435 miles.

Assuming:

12 = tons per vehicle

45 = vehicle availability per company

20 = hours operating time daily

10 = miles in the hour

1 = hour for each relay terminal operation
(average 1 terminal per 125 miles)

First, compute turnaround time:

$$\begin{aligned} \text{TT} &= \frac{\text{round-trip distance}}{\text{rate of march}} + \text{relay terminal time} \\ &= \frac{435}{10} + 2 = 45.5 \text{ hours} \end{aligned}$$

Then, substitute in the formula:

$$\frac{4,800 \times 45.5}{12 \times 45 \times 20} = 20.2 \text{ or } 21 \text{ companies}$$

c. *Sustained Hauls (Continuous Operation)*. In sustained forward hauls using only trucks, not semitrailers in relays, it is necessary to consider operating turnaround (including loading and unloading) and the daily operating time. To determine the number of truck companies required to move a given forward tonnage daily, use the following formula.

$$\frac{\text{Daily forward tonnage} \times \text{operating turnaround}}{\text{Tons per veh} \times \text{veh available per co} \times \text{operating time in hours (daily)}} = \text{truck companies required}$$

EXAMPLE: Determine the number of light truck companies, equipped with 2½-ton trucks, required to move an average tonnage of 5,000 short tons daily for a round-trip distance of 52 kilometers.

Assuming:

4 = tons per vehicle

45 = vehicle availability per company

20 = hours operating time daily

2.5 = hours for loading and unloading

16 = kilometers in the hour

First, compute operating turnaround time:

$$\begin{aligned} \text{TT} &= \frac{\text{round trip distance}}{\text{rate of march}} + \text{loading and unloading time} \\ &= \frac{52}{16} + 2.5 \\ &= 5.75 \text{ hours} \end{aligned}$$

Then, substitute in the formula:

$$\frac{5,000 \times 5.75}{4 \times 45 \times 20} = 7.9 \text{ or } 8 \text{ companies}$$

3.35 Motor Movement in Snow

Depth of snow
(inches)

Special measures required for movement

3	None.
9	Rear chains.
6-18	Chains on all wheels; traction devices on leading vehicles to break the trail. Under some snow conditions, a snowplow may be required to break a path for wheeled vehicles.
18 or more	Snowplow required.

3.36 Time Elements in Supply Operations

The time elements given below represent an approximated average under combat conditions and should be used as a guide only when actual-experience figures are not available.

	Minutes	
	Daylight	Darkness
<i>Class I</i>		
Unloading rations for one division at class I distributing point and prepare for distribution to battle groups or units of similar size.....	100	125
Distribution of class I supplies to battle group or unit of similar size by higher echelon at one distributing point.....	20	20
Distribution of class I supplies to separate battalion or unit of similar size by higher echelon.....	15	15
Preparation of 1 day's class I supplies for issue at battle group or battalion class I distributing point.....	30	45
Physical distribution by battle group or battalion supply agencies of 1 day's class I supplies (transfer of loads) to kitchen.....	15	20
Unloading kitchen equipment from trucks, set up, and be prepared to begin cooking (or vice versa).....	20	20
Breakdown of subsistence into three meals at kitchen (breakdown accomplished by mess personnel).....	15	20
Preparing, cooking, and being ready to serve a hot meal, starting with a hot kitchen. (Issue of subsistence for cold noon meal included if hot meal being prepared is breakfast.).....	120	150
Serving a hot meal to troops from a kitchen truck with majority of men being served at the truck.....	45	60
Serving a hot meal to troops by means of carrying parties (when kitchen is located within a 1,000-yard radius of company).....	90	120
<i>Class II and IV*</i>		
To load 2½-ton trucks at distributing or supply points:		
Class II and IV.....	30	30
Fortification materials, class IV....	50	50
To load 1½-ton trailers:		
Class II and IV.....	12	12
Fortification materials, class IV....	30	30
<i>Class V*</i>		
To load 2½-ton trucks at ammunition distributing or supply points.....	30	50
To load 1½-ton trailers.....	12	30
To unload 2½-ton ammunition vehicles.....	15	30
To unload 1½-ton trailers.....	6	12

* When trucks and trailers are overloaded, increase the time by the percentage of the overload.

3.37 Water Supply

a. Water Requirements. Values given are for planning purposes in temperate zones. For extremes of heat or cold, requirements vary considerably.

Truck	Terrain	Gallons per day
2½-ton, 6 × 6.....	Level, rolling.....	½
	Mountainous.....	½ to 1
5-ton, 6 × 6.....	Level, rolling.....	1
	Mountainous.....	1 to 2

b. Vehicle Carrying Capacities. A full 5-gallon water can weighs 50 pounds; the volume of the can is 1.4 cubic feet.

Vehicle	Carrying capacity, full 5-gal. can	
	Off highway	On highway
¼-ton trailer.....	10	20
1½-ton trailer.....	60	120
2½-ton truck, M35.....	100	200
2½-ton truck, M135.....	100	200
5-ton truck, M54.....	200	370
12-ton semitrailer, M127.....	480	593

3.38 Highway Capability Estimates

a. Definitions. The following definitions are applicable to this discussion of capacity and capability:

- (1) *Basic capacity.* The maximum number of vehicles that can pass over a highway during a 24-hour period, based upon a safe operating vehicle speed and interval, considering vehicle and pavement types.
- (2) *Operational capacity.* The maximum number of vehicles that can pass over a highway in a 24-hour period, derived from estimates of basic capacity with allowances for driver characteristics, unforeseen operational developments, vehicle casualties, driver changes, and essential preventive maintenance en route.
- (3) *Practical daily capacity.* The maximum number of vehicles that can pass over a highway per day, considering highway characteristics and operating conditions.
- (4) *Capability.* The maximum number of short tons of payload per day which can be moved over a highway, considering type of roadway, maintenance, hills, curves, weather, other traffic, types of vehicles used, and other limiting factors.

b. General. The capacity of a highway to support a normal or a maximum vehicular movement is determined by a number of factors: vehicle

types and average loads, traffic data, type and width of surface and shoulders, base type and thickness, subsoil type and condition, curves and gradients, moisture and temperature, number of traffic lanes, and operational factors. No one highway movement is apt to be affected by all of these basic factors. Conditions dictate which factors must be used to estimate the capability of a highway. Tonnage movement which exceeds the capacity of any part of the road net should not be planned unless reconstruction or heavy maintenance to increase the capacity of the inadequate highway section or bridge is also planned; otherwise, the load must be distributed on alternate routes. If an alternate route is not available or if the tonnage is not reduced, the planner can expect the highway or bridge to deteriorate rapidly and any sustained operation to be disrupted. In addition, maintenance vehicles and personnel may limit capacity by interference with the flow of traffic. A workable method for determining the tonnage capability of a highway is explained in *c* and *d* below. Sufficient vehicle types (foreign or domestic) have been included to provide a basis for estimating the capability of any highway. This method is based on the assumption that the highway bridges (dimensions and supporting characteristics) are adequate, or will be improved, to carry the estimated loads. Capabilities in the table in *e* below may be used when specific and detailed highway information is not available.

c. Basic Factors.

- (1) *Surface type (table I).* The types of road surfaces and basic and operational capacities are shown in table I. If the vehicle in question does not correspond exactly to one in the table, the analyst should select the basic or operational capacity for the vehicle that is most similar to the vehicle in question.
- (2) *Surface and shoulder width (table II).* For a two-way movement, the ideal single highway is 24 feet wide and has shoulders at least 12 feet wide. The shoulder factor should be considered only for maintaining maximum capacity, not for increasing capacity. If there are no shoulders or if they are less than 12 feet wide (7 feet for one-way movement), a reduction factor should be used. Table II-A is used if the widths of the surface and shoulder are not given separately and the width of the travelled way only is known. This may

occur in connection with gravel or earth roads.

- (3) *Curve and gradient (table III).* Curves and gradients affect the capacity of roads. Radius of simple curvature is measured from the center of the circle to the middle of the road. Gradient, or slope percentage, is the ratio of the vertical rise to the horizontal distance travelled. The ruling grade of a road is the gradient used.
- (4) *Moisture and temperature (table IV).* Moisture and temperature affect the capacity of road surfaces. The type of soil upon which the roadway is constructed becomes increasingly important as surface rigidity decreases. Heavy concentrations of, or long exposures to, moisture affect the subsoil of even the highest type of pavement, while both the surface and the subsoil of low type or unimproved roads are immediately affected. The degree of moisture can be determined by studying data on soil conditions and on seasonal weather variations. Tables IV and VI are guides for determining the effects of moisture and temperature on the capacity of a highway to withstand sustained and maximum vehicular movement. Reports of good, fair, and poor surface conditions must be evaluated by the analyst, who should compare them with other reports, photographs, and information about the road network.
- (5) *Number of traffic lanes.*
 - (a) *One lane.* Since roads less than 18 feet wide should be used for one-way movement only, the whole adjusted sustained capacity is in one direction. If a one-way movement is to be maintained over a period of time, some provision must be made for the return of empty trucks, either by alternate routes or by a reduction in the hours of forward operation. The one-way factors shown in table II consider one forward lane only although a 17-foot road with good shoulders also has limited usefulness for return of empties.
 - (b) *Two lanes.* Roads over 18 feet in width can support one-way or two-way movement. Since the capacities shown in table I are for all traffic, the ad-

justed capacity will be in terms of total traffic moving in both directions for two-way movement. Therefore, half of this total two-way movement represents the highway capacity in one direction.

- (c) *Multilane.* A multilane, divided highway of a given width can support a greater volume of traffic than an undivided highway of the same width because all traffic on any one lane is moving in the same direction. Since total traffic may move in one or both directions, the adjusted capacity may be determined in the manner described in (b) above. The greater inherent capacities of multilane systems are allowed for in table II.

(6) *Operational.*

- (a) *Turning and cross movements.* Although the turning and cross movement factors varies between 1.0 and 0.5, depending on the size and nature of the overall operation, the average factor of 0.85 may be used when estimating highway capacity.
- (b) *Hours of running time.* Running time is usually determined by the hours of daylight or darkness. In no case should the running time for a sustained movement be more than 18 hours a day. When a one-way movement is planned over a route with no alternate, the running time selected must include time for returning empties and for turning around.
- (c) *Weather and other factors.* Certain operational factors, such as the weather, tactical situation, and movements of unknown vehicles, cannot be accurately assessed beforehand.
- (7) *Base thickness.* Factors applicable to base thickness may be required. For the transportation planner, this is normally not necessary, since the thickness of base in road construction is usually adequate. Should the base not be adequate, thereby producing a factor other than unity, the quantities in table V can be used.

d. *Making the Estimate.*

- (1) *General.* Since conditions dictate the factors which must be used when esti-

imating a highway's capacity, the analyst must consider each problem separately. In some situations a factor of 1.0 will apply; in such cases the highway capacity is not affected. Methods and examples of estimating highway capacity to support normal and maximum movements are given below.

(2) *Methods.*

- (a) *Normal movement.* To estimate sustained highway capability, determine surface type and multiply the operational capacity in number of trucks (table I) successively by each of the following factors that is applicable: width of surface and shoulder, curve and gradient, moisture and temperature, base thickness, and operational. The product is for a 24-hour day. It should then be adjusted in one of two ways as follows:

1. Adjust the figure to reflect the actual working hours in the day by multiplying it by the following fraction:

$$\frac{\text{Working hours in day}}{24}$$

2. If making a strategic-type estimate for which definite information as to method of operation is not known, the figure should be adjusted to reflect daylight hours only by multiplying it by the following fraction:

$$\frac{\text{Daylight hours in day}}{24}$$

Adjust the figure further to show movement in one direction only by dividing by 2 if a two-way movement. If movement is one-way, no further reduction is necessary since the all-traffic capacity represents loaded movement in one direction. Convert to tonnage capability.

- (b) *Maximum movement.* To estimate the capability of a highway to support a maximum movement with no road maintenance, multiply the basic daily capacity successively by the surface and shoulder width factors, the curve and gradient factor, the turning and cross movement factor, and the base thickness factor, if applicable. The other factors are not used as multipliers

in making a maximum estimate, since this type of operation calls for maximum tonnage within a short time, with no requirement for sustained movement. Adjustments of the figure thus obtained are made in the same manner as for the normal movement described in (a) above except that the working day is 20 hours. Owing to the influence of the surface on such movements when no road maintenance is performed, high type surfaces can sustain movements for longer periods than low type surfaces (table VI).

- (3) *Highway capability checklist.* In order to eliminate or minimize the omission of important considerations when estimating highway capability, the following checklist may be used as a guide.

(a) Technical planning information.

1. Origin and destination.
2. Surface type and width.
3. Vehicle type and average load.
4. Shoulder type and width.
5. Base type and thickness.
6. Alinement (curvature and gradient).
7. Subsoil type and condition.
8. Traffic and bridge data.

(b) Planning guide factors.

1. Operational or basic capacity (vehicles per day).
2. Surface and shoulder width.
3. Curve and gradient.
4. Pavement deterioration (moisture and temperature).
5. Base thickness.
6. Operational factors.

(c) Planning estimate.

1. Practical daily capacity (vehicles per day).
2. Capability (short tons per day).

- (4) *Examples.* (Slide-rule calculations are sufficiently accurate for these estimates.)

(a) *Bituminous-surface treatment.*

1. *Problem.* What is the sustained capability of a bituminous-surface treated highway where—

Surface is 12 to 20 feet wide and has clay subsoil.

Shoulder width is 6 to 7 feet.

Ruling gradient is 10 percent.

Minimum curve radius is 100 feet.

It is the dry season.

Alternate routes are available for the return of empty trucks.

Operations are 12 hours per day.

Cargo trucks averaging 3 tons are used.

2. *Solution.* The operational capacity for 3-ton cargo vehicles on bituminous-surface treatment is 16,900 vehicles per day (table I). Inasmuch as surface widths vary from 12 to 20 feet, the estimate must be for a one-way movement. The returning empty trucks will use alternate routes. The surface width factor (table II) is 0.68 for a 12-foot surface; the shoulder factor is 0.99. The curve and gradient factor for 10-percent grades is 0.5 (table III). The moisture factor is 0.6 for bituminous-surface treatment in dry weather with clay subsoil (table IV). The average factor for turning and cross movement is 0.85. Therefore the calculation for this estimate is $16,900 \times 0.68 \times 0.99 \times 0.5 \times 0.6 \times 0.85$ or 2,910 vehicles per day. Multiplying the number of vehicles by 3 (the average payload in short tons carried by each vehicle) gives a highway capability of 8,730 short tons per 24-hour day for a sustained period. Since the operation is only for 12 hours per day, the net capability is half of 8,730 or 4,365 short tons per day. It should be noted that this problem involves a 12-hour, one-direction movement because alternate routes are available for the returning empties. Had no alternate routes been available, the running time, which must include time for changing direction and returning empties, might have been 8 hours forward, 8 hours returning, and 2 hours for transition. This makes a total of 18 hours per day, which is the recommended maximum for sustained movement.

(b) *Gravel surface.*

1. *Problem.* What is the sustained capability of a graveled-surfaced road where—

Surface is 18 feet wide with a clay base.

Shoulder width is 2 feet.

Ruling gradient is 10 percent.

Minimum curve radius is 200 feet.

It is the wet season.

No alternate routes are available.

Operations are 14 hours per day.

Three-ton cargo trucks are used.

2. *Solution.* The operational capacity of a gravel surface to support 3-ton cargo trucks is 6,700 vehicles per day (table I). A two-way movement is planned because the surface is 18 feet wide and no alternate routes are available. According to table II, the surface-width factor is 0.75; the shoulder-width factor is 0.8. The curve and gradient factor is 0.5 (table III). Table IV shows the moisture factor to be 0.10 for a wet gravel road with clay subsoil. The factor of 0.85 is used for turning and cross movement. The calculation for this estimate is $6,700 \times 0.75 \times 0.8 \times 0.5 \times 0.10 \times 0.85$ or 171 vehicles per day with vehicles traveling in both directions. Therefore, 171 divided by 2 will give 85 vehicles for a one-direction movement. Then 85×3 (average number of tons carried by each vehicle) equals a capability of 255 short tons per 24-hour day. Using a 14-hour working day, the net capability is $\frac{14}{24} \times 255$ or 149 short tons per day for sustained operations.

(c) *Four-lane, divided highway.*

1. *Problem.* What is the sustained capability of a four-lane, divided highway where—

Surface is cement concrete with clay subsoil

Width of each two-lane section is 24 feet.

Shoulders are 8 feet wide.

Ruling gradient is 4 percent.

Minimum curve radius is 1,000 feet.

The weather is dry.

Operations are 12 hours per day.

Three-ton cargo trucks are used.

2. *Solution.* Use the operational capa-

city of 16,900 vehicles per day for a cement concrete surface as the basic figure for the computation (table I). The surface width factor for a 4-lane, divided highway with two 24-foot surfaces is 2.5 and the shoulder width factor is 1.0 (table II). The curve and gradient factor (table III) is 0.95 for 4-percent grades. The moisture factor for cement concrete with clay subsoil in dry condition is 1.0 (table IV). The average factor for turning and cross movement is 0.85. Thus the calculation for sustained movements on this section of highway is: $16,900 \times 2.5 \times 1.0 \times 0.95 \times 1.0 \times 0.85$ or 34,100 vehicles. This figure represents the number of vehicles per 24-hour day that is the practical total capacity of the highway. Since returning empty trucks will use the highway also, the cargo movement forward will be one-half of the capacity. Therefore the traffic in one direction will be 17,050 vehicles per day. Because operations are for only 12 hours per day, 17,050 must be divided by 2 which gives a net capacity in one direction of 8,525 vehicles per day. The sustained capability in tonnage will be $8,525 \times 3$ or 25,575 short tons per day.

(d) *Maximum movement over four-lane, divided highway.*

1. *Problem.* What is the maximum movement capability of the four-lane, divided highway described in (c) above?

2. *Solution.* Procedure is the same as that outlined in (c) above except basic capacity is used instead of operational capacity (table I), the moisture factor is not considered, and running time is increased to 20 hours per day. The computation is $21,100 \times 2.5 \times 1.0 \times 0.95 \times 0.85$ or 42,600 vehicles per 24-hour day traveling in both directions. Since operations are for 20 hours per day and only forward traffic is desired, $42,600 \times \frac{20}{24} \div 2$ would give 17,700

vehicles per day forward. The net short term tonnage capability is then $17,700 \times 3$ or 53,100 short tons per day. This capability for cement concrete in dry weather could be

maintained on a maximum basis for 30 days (table VI), giving a total projected capability on a maximum or "crash" basis of 1,593,000 short tons.

Table I. Highway daily capacity: basic and operational.

Surface type	Vehicle type (highway tonnage ratings)	Average speed		Vehicle interval		Capacity in vehicles per 24-hours for all traffic ^a	
		(mph)	(kmph)	(ft)	(meters)	Basic ^a	Operational ^b
Cement concrete, bituminous concrete, intermediate bituminous and bituminous-surface treated.	3T trk (avg for 2-axle)-----	25	40	300	91	21,100	16,900
	5T trk-----	25	40	300	91	21,100	16,900
	10T trk or stlr-----	25	40	325	99	19,200	15,400
	18T stlr-----	25	40	375	114	16,800	13,400
	50T stlr-----	20	32	400	122	12,500	10,000
	admin veh-----	25	40	250	76	25,200	20,200
Waterbound macadam, gravel, and crushed stone.	3T trk (avg for 2-axle)-----	20	32	(^c) 600	183	8,400	6,700
	5T trk-----	20	32	600	183	8,400	6,700
	10T trk or stlr-----	20	32	700	213	7,700	6,200
	18T stlr-----	20	32	700	213	7,700	6,200
	50T stlr-----	15	24	700	213	5,800	4,600
	admin veh-----	20	32	500	152	10,600	8,500
Improved earth-----	3T trk (avg for 2-axle)-----	20	32	(^c) 800	244	6,300	5,000
	5T trk-----	20	32	800	244	6,300	5,000
	10T trk or stlr-----	20	32	800	244	6,300	5,000
	18T stlr-----	20	32	800	244	6,300	5,000
	50T stlr-----	15	24	800	244	5,000	4,000
	admin veh-----	20	32	700	213	7,700	6,200
Unimproved earth-----	3T trk (avg for 2-axle)-----	15	24	(^c) 1,000	305	3,800	3,000
	5T trk-----	10	16	1,000	305	2,500	2,000
	10T trk or stlr-----	10	16	1,000	305	2,500	2,000
	18T stlr-----	10	16	1,000	305	2,500	2,000
	50T stlr-----	10	16	1,000	305	2,500	2,000
	admin veh-----	15	24	1,000	305	3,800	3,000

^a Basic capacity is based upon the assumptions that a 24-foot surface width (two lanes) is used; a 12-foot shoulder is on each side; there is straight and level alignment; surface and subsoil are in excellent condition; traffic control is provided; movements are sustained; and vehicles travel in both directions.

^b Operational capacity is approximately 80 percent of basic capacity.

^c Intervals increase as quality of surface decreases due primarily to the dust hazard.

Table II. Surface and shoulder width factors.

Type of movement	Number of lanes	Surface			Shoulder		
		Width (ft)	Factor		Width (ft)	Factor	
			Divided highway	Undivided highway		Divided highway	Undivided highway
One-way-----	1	8		0.44	0		0.74
	1	9		0.51	1		0.79
	1	10		0.58	2		0.85
	1	11		0.64	3		0.93
	1	12		0.68	4		0.97

Table II. Surface and shoulder width factors—Continued.

Type of movement	Number of lanes	Surface			Shoulder		
		Width (ft)	Factor		Width (ft)	Factor	
			Divided highway	Undivided highway		Divided highway	Undivided highway
	1	12-18 ^a		0.68	5		0.98
	1	>18		(^b)	6		0.99
	1				7		1.00
	1				>7		1.00
Two-way-----	2	18		0.75	0		0.70
	2	19		0.80	1		0.75
	2	20		0.85	2		0.80
	2	21		0.90	3		0.85
	2	22		0.95	4		0.90
	2	23		0.98	5		0.94
	2 or 3 ^c	24		1.00	6		0.97
	2 or 3	24-35		1.00	7		0.98
	2 or 3	>35		1.00	8		0.98
	2 or 3				9		0.99
	2 or 3				10		0.99
	2 or 3				11		0.99
	2 or 3				12		1.00
	2 or 3				>12		1.00
	4	36	2.0	1.8	0-2	0.80	0.80
	4	42	2.2	2.0	2-7	0.90	0.90
	4	48	2.5	2.2	7-12	1.00	1.00
	4				>12	1.00	1.00

^a For pavement widths between 12 and 18 feet, consider $\frac{1}{2}$ the width over 12 feet as additional shoulder width.

^b For one-way movements on pavements more than 18 feet in width, the factor for half the actual pavement width will be selected, and will then be doubled to reflect the two lines of traffic that can effectively use pavements 18 feet or more in width.

^c Even though a road has three lanes, the capacity estimate should be based on two-lane traffic movement, thereby eliminating the inherent inefficiency and loss of capacity caused by three lanes of movement.

Table IIA. Combined surface and shoulder factors when only width of travelled way is known.

Width of travelled way (feet)	Factor	
	One-way movement	Two-way movement
8	0.33	
9	0.36	
10	0.39	
11	0.42	
12	0.45	
13	0.46	
14	0.47	
15	0.48	
16	0.53	
17	0.58	
18	0.62	0.52
19	0.65	0.55
20	0.675	0.575
21	0.675	0.60
22	0.675	0.63
23		0.66
24		0.68

Table II-A. Combined surface and shoulder factors when only width of travelled way is known—Continued.

Width of travelled way (feet)	Factor	
	One-way movement	Two-way movement
25		0.71
26		0.73
27		0.75
28		0.77
29		0.79
30		0.80
31		0.82
32		0.835
33		0.84
34		0.85
35		0.86
36		0.87
37		0.87
38		0.87 ¹
39		0.87
40		0.87
41		0.875
42		0.88
43		0.90
44		0.92
45		0.94
46		0.96
47		0.98
48		1.00
49		1.00
50		1.00

Table III. Curve and gradient factors.*

Curve radius (ft)	Radius of Curvature						Gradient						
	Factors						Per-cent	Factors					
	3-T Trk	5-T Trk	10-T Stlr or trk	8-T Stlr	50-T Stlr	Admin veh		3-T Trk	5-T Trk	10-T Stlr or trk	18-T Stlr	50-T Stlr	Admin veh
< 50	0.40	0.40	0.20	.20	.20	.65	< 2	1.00	1.00	1.00	1.00		1.00
50	0.40	0.40	0.20	.20	.20	.65	2	1.00	1.00	1.00	1.00	.98	1.00
63	0.50	0.51	0.29	.25	.23	.78	2½	1.00	1.00	1.00	1.00	.97	1.00
75	0.60	0.63	0.38	.30	.27	.85	2¾	1.00	1.00	1.00	.99	.94	1.00
88	0.70	0.71	0.44	.35	.31	.91	2½	1.00	1.00	.99	.98	.93	1.00
100	0.75	0.78	0.50	.41	.35	.94	2½	1.00	1.00	.98	.97	.92	1.00
113	0.78	0.83	0.55	.46	.40	.97	2¾	1.00	1.00	.98	.96	.89	1.00
125	0.82	0.88	0.61	.54	.46	.98	2¾	1.00	1.00	.97	.94	.88	1.00
138	0.85	0.91	0.66	.60	.52	.99	3	.99	1.00	.95	.93	.86	1.00
150	0.88	0.94	0.71	.65	.57	1.00	3¼	.98	1.00	.93	.91	.83	1.00
163	0.90	0.96	0.75	.71	.62	1.00	3½	.98	1.00	.91	.88	.81	1.00
175	0.92	0.98	0.78	.74	.67	1.00	3¾	.97	1.00	.88	.85	.78	1.00
188	0.94	0.99	0.82	.78	.71	1.00	4	.95	.99	.86	.82	.75	1.00
200	0.95	0.99	0.86	.82	.75	1.00	4¼	.94	.99	.83	.78	.71	1.00
213	0.97	1.00	0.88	.85	.78	1.00	4½	.93	.98	.78	.74	.67	1.00
225	0.98	1.00	0.91	.88	.81	1.00	4¾	.90	.96	.75	.71	.63	1.00
238	0.98	1.00	0.93	.91	.83	1.00	5	.88	.94	.70	.65	.57	1.00
250	0.99	1.00	0.95	.93	.86	1.00	5½	.85	.91	.65	.60	.52	.99
263	0.99	1.00	0.96	.94	.87	1.00	6	.83	.88	.60	.54	.46	.98
275	1.00	1.00	0.98	.96	.89	1.00	6½	.78	.83	.55	.47	.40	.97
288	1.00	1.00	0.98	.97	.91	1.00	7	.75	.78	.50	.41	.35	.94
300	1.00	1.00	0.99	.98	.93	1.00	8	.70	.71	.44	.36	.31	.91
313	1.00	1.00	0.99	.99	.94	1.00	9	.60	.63	.38	.30	.27	.85
325	1.00	1.00	1.00	1.00	.95	1.00	10	.50	.52	.29	.25	.23	.78
338	1.00	1.00	1.00	1.00	.96	1.00	11	.40	.40	.20	.20	.20	.65
350	1.00	1.00	1.00	1.00	.98	1.00	>11	.40	.40	.20	.20	.20	.65
>350	1.00	1.00	1.00	1.00		1.00							

* Both factors should not be used; apply only the factor which gives the minimum capacity.

Table IV. Factors used to determine effect of moisture and temperature on highway capacity.

Surface type	Vehicle type (highway tonnage rating)	Type and condition of Subsoil ¹														
		Sand and/or gravel					Clay					Silt ²				
		Dry	Moist	Wet	Frozen	Freeze & thaw	Dry	Moist	Wet	Frozen	Freeze & thaw	Dry	Moist	Wet	Frozen	Freeze & thaw
Cement concrete, bituminous concrete.	3T trk (avg for 2-axle)	1.00	1.00	0.95	1.00	0.95	1.00	1.00	0.80	1.00	0.75					
	5T trk	1.00	1.00	0.95	1.00	0.95	1.00	1.00	0.80	1.00	0.75					
	10T trk or stlr	0.90	0.90	0.90	1.00	0.90	0.90	0.90	0.80	1.00	0.75					
	18T stlr	0.90	0.90	0.90	1.00	0.90	0.90	0.90	0.70	1.00	0.65					
	50T stlr	0.90	0.90	0.85	1.00	0.80	0.90	0.90	0.70	1.00	0.65					
	Admin veh	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	1.00	0.90					
Intermediate bituminous.	3T trk (avg for 2-axle)	0.90	0.90	0.80	1.00	0.80	0.90	0.90	0.55	1.00	0.50					
	5T trk	0.90	0.90	0.80	1.00	0.80	0.90	0.90	0.55	1.00	0.50					
	10T trk or stlr	0.80	0.80	0.70	1.00	0.70	0.80	0.80	0.45	1.00	0.40					
	18T stlr	0.80	0.80	0.70	1.00	0.70	0.80	0.80	0.45	1.00	0.40					
	50T stlr	0.80	0.80	0.60	1.00	0.60	0.80	0.80	0.45	1.00	0.40					
	Admin veh	1.00	1.00	0.90	1.00	1.00	1.00	1.00	0.65	1.00	0.65					
Bituminous surface treatment.	3T trk (avg for 2-axle)	0.60	0.70	0.30	1.00	0.30	0.60	0.70	0.20	1.00	0.10	0.40	0.40	0	1.00	0
	5T trk	0.40	0.50	0.30	1.00	0.30	0.40	0.50	0.20	1.00	0.12	0.25	0.25	0	1.00	0
	10T trk or stlr	0.30	0.35	0.20	1.00	0.20	0.30	0.35	0.10	1.00	0.025	0.15	0.15	0	1.00	0
	18T stlr	0.25	0.30	0.15	1.00	0.15	0.25	0.30	0.07	1.00	0.025	0.10	0.10	0	1.00	0
	50T stlr	0.25	0.30	0.15	1.00	0.15	0.25	0.30	0.07	1.00	0.025	0.10	0.10	0	1.00	0
	Admin veh	0.80	0.80	0.60	1.00	0.60	0.80	0.80	0.45	1.00	0.25	0.50	0.50	0	1.00	0
Waterbound macadam, gravel, crushed stone.	3T trk (avg for 2-axle)	0.25	0.35	0.15	0.35	0.10	0.25	0.45	0.10	1.00	0.025	0.15	0.15	0	1.00	0
	5T trk	0.25	0.35	0.15	0.35	0.10	0.25	0.45	0.12	1.00	0.07	0.15	0.15	0	1.00	0
	10T trk or stlr	0.20	0.30	0.10	0.30	0.05	0.20	0.30	0.025	1.00	0	0.10	0.10	0	1.00	0
	18T stlr	0.10	0.25	0.05	0.25	0.05	0.10	0.25	0.025	1.00	0	0.05	0.05	0	1.00	0
	50T stlr	0.10	0.25	0.05	0.25	0.05	0.10	0.25	0.025	1.00	0	0.05	0.05	0	1.00	0
	Admin veh	0.40	0.50	0.30	0.50	0.15	0.40	0.55	0.25	1.00	0.15	0.30	0.30	0	1.00	0
Improved earth	3T trk (avg for 2-axle)	0.15	0.35	0.10	0.35	0.15	0.30	0.65	0	1.00	0	0.05	0.05	0	1.00	0
	5T trk	0.17	0.35	0.12	0.35	0.17	0.30	0.65	0	1.00	0	0.05	0.05	0	1.00	0
	10T trk or stlr	0.10	0.30	0.05	0.30	0.10	0.17	0.40	0	1.00	0	0	0	0	1.00	0
	18T stlr	0.05	0.30	0.025	0.25	0.05	0.17	0.40	0	1.00	0	0	0	0	1.00	0
	50T stlr	0.05	0.25	0.025	0.25	0.05	0.17	0.40	0	1.00	0	0	0	0	1.00	0
	Admin veh	0.25	0.50	0.20	0.50	0.25	0.55	1.00	0	1.00	0	0.15	0.15	0	1.00	0
Unimproved earth	3T trk (avg for 2-axle)	0.15	0.25	0.07	0.25	0.07	0.30	0.55	0	2.00	0	0.05	0.05	0	2.00	0
	5T trk	0.17	0.25	0.07	0.25	0.07	0.30	0.55	0	2.00	0	0.05	0.05	0	2.00	0
	10T trk or stlr	0.10	0.20	0.025	0.20	0.025	0.17	0.30	0	2.00	0	0	0	0	2.00	0
	18T stlr	0.05	0.20	0	0.20	0	0.17	0.30	0	2.00	0	0	0	0	2.00	0
	50T stlr	0.05	0.20	0	0.20	0	0.17	0.30	0	2.00	0	0	0	0	2.00	0
	Admin veh	0.25	0.40	0.12	0.40	0.10	0.55	0.80	0	2.00	0	0.15	0.15	0	2.00	0

¹ Factors are based upon the assumption that the road has been properly constructed, and thickness of base is adequate.² This type of subsoil normally is not found under high-type pavements; consequently, factors are not shown. However, where high-type pavements have been constructed over silt subsoil in northern areas, capacities are reduced during certain times of the year due to subsoil weakening. The extent of reduction will depend upon the judgment of the analyst.

Table V.. Base thickness factors (temperate zones).

Surface type	Base thickness (inches)*									
	1	2	3	4	5	6	7	8	9	10
Cement concrete, bituminous concrete.....	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Block type surface.....	0.13	0.26	0.38	0.49	0.62	0.75	0.88	1.0		
Intermediate bituminous, bituminous surface treated.....	0.2	0.35	0.5	0.65	0.83	1.0				
Waterbound macadam, gravel, crushed stone (total thickness)---	0.3	0.52	0.79	1.0						

* Interpolation should be used to obtain factor if fractions of an inch are encountered.

Table VI. Number of days surfaces can support a maximum movement without road maintenance.

Surface type	Vehicle type (highway tonnage ratings)	Type and Condition of Subsoil ¹											
		Sand and/or gravel				Clay				Silt ²			
		Dry	Moist	Wet	Freeze & thaw	Dry	Moist	Wet	Freeze & thaw	Dry	Moist	Wet	Freeze & thaw
Cement concrete, bituminous concrete.	3T trk (avg for 2- axle).....	30	30	20	20	30	30	10	10				
	5T trk.....	30	30	20	20	30	30	10	10				
	10T trk or semi.....	30	30	20	20	30	30	10	10				
	18T stlr.....	30	30	20	20	30	30	10	10				
	50T stlr.....	30	30	20	20	30	30	10	10				
	Admin veh.....	90	90	50	50	90	90	50	50				
Intermediate bituminous.....	3T trk (avg for 2- axle).....	15	15	5	5	15	15	2	2				
	5T trk.....	15	15	5	5	15	15	2	2				
	10T trk or semi.....	15	15	5	5	15	15	2	2				
	18T stlr.....	15	15	5	5	15	15	2	2				
	50T stlr.....	15	15	5	5	15	15	2	2				
	Admin veh.....	50	50	20	20	50	50	10	10				
Bituminous surface treatment...	3T trk (avg for 2- axle).....	10	10	3	3	10	10	1	1	2	2	0.50	0.50
	5T trk.....	10	10	3	3	10	10	1	1	2	2	0.50	0.50
	10T trk or semi.....	10	10	3	3	10	10	0.75	0.75	2	2	0.25	0.25
	18T stlr.....	10	10	3	3	10	10	0.75	0.75	2	2	0.25	0.25
	50T stlr.....	10	10	3	3	10	10	0.75	0.75	2	2	0.25	0.25
	Admin veh.....	20	20	10	10	20	20	10	10	5	5	2	2
Waterbound macadam, gravel, crushed stone.	3T trk (avg for 2- axle).....	5	5	1	1	5	5	0.62	0.62	0.50	0.50	<0.25	<0.25
	5T trk.....	5	5	1	1	5	5	0.62	0.62	0.50	0.50	<0.25	<0.25
	10T trk or semi.....	5	5	0.5	0.5	5	5	0.37	0.37	0.50	0.50	<0.25	<0.25
	18T stlr.....	5	5	0.5	0.5	5	5	0.37	0.37	0.50	0.50	<0.25	<0.25
	50T stlr.....	5	5	0.5	0.5	5	5	0.37	0.37	0.50	0.50	<0.25	<0.25
	Admin veh.....	10	10	2	2	10	10	1.5	1.5	1	1	<0.25	<0.25
Improved earth.....	3T trk (avg for 2- axle).....	5	5	<0.25	<0.25	5	5	<0.25	<0.25	0.25	0.25	<0.25	<0.25
	5T trk.....	5	5	<0.25	<0.25	5	5	<0.25	<0.25	0.25	0.25	<0.25	<0.25
	10T trk or semi.....	5	5	<0.25	<0.25	5	5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	18T stlr.....	5	5	<0.25	<0.25	5	5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	50T stlr.....	5	5	<0.25	<0.25	5	5	<0.25	<0.25	0.25	0.25	<0.25	<0.25
	Admin veh.....	10	10	<0.25	<0.25	10	10	10	10	0.25	0.25	<0.25	<0.25

See footnotes at end of table.

Table VI. Number of days surfaces can support a maximum movement without road maintenance—Continued

Surface type	Vehicle type (highway tonnage ratings)	Type and Condition of Subsoil ¹											
		Sand and/or gravel				Clay				Silt ²			
		Dry	Moist	Wet	Freeze & thaw	Dry	Moist	Wet	Freeze & thaw	Dry	Moist	Wet	Freeze & thaw
Unimproved earth.....	3T trk (avg for 2- axle).....	5	5	<0.25	<0.25	5	5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	5T trk.....	5	5	<0.25	<0.25	5	5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	10T trk or semi.....	5	5	<0.25	<0.25	5	5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	18T stlr.....	5	5	<0.25	<0.25	5	5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	50T stlr.....					5	5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	Admin veh.....	10	10	<0.25	<0.25	10	10	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25

¹ Under frozen conditions, a maximum movement can be supported for the duration of the freeze.² See note 2, table IV.

e. Making the Estimate with Limited Information. The following table may be used as a guide in the absence of more accurate data for estimating the supply support tonnage capabilities of highways under varied conditions, assuming operations are sustained, adequate road maintenance is provided, and each road bears two-way traffic. In using the

reductions portion of the chart below, multiply the daily forward tonnage successively by each of the three factors that is applicable (narrow roadway, one of the next three concerning terrain, and seasonal bad weather). It should be noted that the seasonal bad weather factor applies only when the estimate is for a sustained period.

Type of road	Daily tonnage forward (ST)			Reductions applicable to various conditions				
	Optimum dispatch route only	Supply traffic (COMMZ)	Supply traffic (combat zone)	Narrow roadway	Rolling terrain	Hilly with curves	Mountainous	Seasonal bad weather
Concrete.....	60,000	36,000	8,400	0.75	0.90	0.70	0.40	0.80
Bituminous.....	45,000	27,000	7,300	0.75	0.90	0.70	0.40	0.70
Bituminous treated.....	30,000	18,000	5,800	0.75	0.80	0.60	0.35	0.60
Gravel.....	10,150	6,090	3,400	0.75	0.80	0.50	0.30	0.40
Earth.....	4,900	2,940	1,600	0.75	0.75	0.40	0.20	0.10

Section IV. MAINTENANCE AND SUPPLY

3.39 Maintenance

a. Organization.

Category	Definition	Echelon	Scope	Performed by	Responsibility of
Organizational...	Work authorized for, performed by, and the responsibility of the using unit.	1st	Care taken of and work done on equipment to keep it in a standard condition of serviceability. Consists of inspecting, cleaning, servicing, and tightening.	Operator or crew.	Company commander.
		2d	Consists of servicing, inspecting, adjusting, and making minor repair and minor replacement.	Unit mechanics.	Company commander.
Field.....	Work performed by mobile or semimobile technical service units in direct support of using units.	3d	Repair and/or replacement of major parts, components, and assemblies, done by units in direct support.	(¹)	(¹)
		4th	Repair and/or replacement of major parts, components, and assemblies; done by units for a geographical area.	Supporting army units.	Army commander.
Depot.....	Work performed by permanent installations using extensive equipment.	5th	Major overhaul or complete rebuild.	Depot units.	Chief of Army Material Command.

¹ For divisions, third echelon is performed by organic support units. Responsible officer is the division commander.

b. Preventive.

(1) *Scope.* Preventive maintenance is the systematic care, inspection, and servicing of equipment to maintain it in serviceable condition and to detect and correct incipient failures before expensive and time-consuming repairs or replacements are required. Preventive maintenance services are performed by vehicle operators and organizational maintenance personnel. Proper operation and use of equipment are just as important to preventive maintenance as are prescribed inspections and services.

(2) *Intervals.* To insure that all important parts of equipment are checked systematically, three types of recorded preventive maintenance services are prescribed. For further details, see TM 38-750.

(a) The daily service performed by the equipment operators or crew each day the equipment is operated.

(b) Periodic services prescribed by pertinent maintenance publications. These services are normally performed by organizational personnel.

(c) Lubrication is performed in accordance with the equipment lubrication order or other maintenance publications.

3.40 Recommended Tire Pressures and Maximum Loads

The table below may be used as a guide for determining inflation pressures and maximum loads for tires. Pressures and loads shown are averages for the different makes of tires. If available, figures from the identification plate or technical manual for a particular vehicle should take precedence, if they differ from those listed below. To obtain better floatation (bearing surface) in soft sand, snow, or mud, tire pressure may be reduced, but pressure below 10 pounds per square inch is not recommended. In extreme cold, tire pressure should be increased 10 percent. Proper pressure should be restored as soon as practicable.

Tire size		Number of plies	Recommended pressure (psi)	Recommended maximum load (lb)
Passenger cars	Trucks, buses, and trailers			
5.50-16	-----	4	30	810
5.90-15	-----	4	24	745
6.00-16	-----	4	28	915
-----	6.00-16	6	45	1,140

Tire size		Number of plies	Recommended pressure (psi)	Recommended maximum load (lb)
Passenger cars	Trucks, buses, and trailers			
6.25-16	-----	4	28	985
6.40-15	-----	4	24	830
6.50-16	-----	4	28	1,050
-----	6.50-16	6	45	1,290
-----	6.50-20	6	50	1,700
-----	6.50-20	8	65	1,950
6.70-15	-----	4	26	920
7.00-15	-----	4	26	1,095
-----	7.00-15	6	45	1,380
-----	7.00-15	8	55	1,555
7.00-16	-----	4	26	1,145
-----	7.00-16	6	45	1,440
-----	7.00-20	8	55	2,000
7.10-15	-----	4	26	990
*7.50-14	-----	4	24	1,085
-----	7.50-15	8	55	1,780
-----	7.50-15	10	80	3,310
-----	7.50-15	12	95	3,660
7.50-16	-----	4	24	1,235
-----	7.50-16	6	45	1,650
-----	7.50-16	8	55	1,860
-----	7.50-17	8	60	2,100
-----	7.50-18	8	60	2,200
-----	7.50-20	8	60	2,375
7.60-15	-----	4	26	1,090
*8.00-14	-----	4	24	1,175
8.00-15	-----	4	26	1,395
8.20-15	-----	4	24	1,415
-----	8.25-15	14	100	4,450
8.25-16	-----	6	34	1,690
-----	8.25-20	10	65	2,900
*8.50-14	-----	4	24	1,265
*9.00-14	-----	4	24	1,355
-----	9.00-15	12	75	4,510
-----	9.00-16	8	45	2,250
-----	9.00-20	8	45	2,775
-----	9.00-20	10	65	3,250
*9.50-14	-----	4	24	1,465
-----	9.75-20	12	70	3,900
-----	9.75-22	12	70	4,200
-----	9.75-24	12	70	4,400
-----	10.00-15	14	85	5,480
-----	10.00-20	12	70	4,000
-----	10.00-22	12	70	4,275
-----	10.00-24	12	70	4,550
-----	10.50-20	12	75	4,700
-----	10.50-22	12	75	5,000
-----	10.50-24	12	75	5,200
-----	11.00-20	12	70	4,500
-----	11.00-22	12	70	4,750
-----	11.25-20	14	80	5,450
-----	11.25-24	14	80	6,050
-----	12.00-20	14	75	5,275
-----	12.00-24	14	75	5,925
-----	12.75-20	16	90	7,200
-----	12.75-24	16	90	8,000
-----	13.50-20	16	95	8,200
-----	13.50-24	16	95	9,100
-----	14.00-20	12	45	5,450

Tire size		Number of plies	Recommended pressure (psi)	Recommended maximum load (lb)
Passenger cars	Trucks, buses, and trailers			
-----	14.00-24	20	90	9,150
-----	16.00-25	20	60	9,475
-----	18.00-24	16	40	13,590

* Tubeless tires.

3.41 Vehicle and Motor Park Checklist

Score (percent)

a. General.

- (1) Is the general appearance of the motor park satisfactory?
- (2) Are gasoline dispensing areas properly maintained?
- (3) Are dirty wiping rags and waste or similar flammable materials properly disposed of?
- (4) Are sufficient fire extinguishers provided? Have they been checked for serviceability?
- (5) Are fire extinguishers accessibly located?
- (6) Are lubricant containers covered, and lubricants kept clean?
- (7) Are lubricant dispensers clean and properly maintained?

b. Maintenance Shop and Records.

- (1) Are tools and equipment properly cleaned, serviced, and secured when not in use?
- (2) Are regulations enforced regarding flammable materials and fuels?
- (3) Are all preventive maintenance inspections properly supervised?
- (4) Are equipment lubrication orders on hand and in use?
- (5) Are appropriate technical manuals and bulletins on hand and readily available?
- (6) Are technical manuals used in the performance of preventive maintenance inspections and services?

Score (percent)

- (7) Are adequate road tests performed on each vehicle as a part of preventive maintenance and inspection services?
- (8) During scheduled preventive maintenance inspections, does the unit diagnose deficiencies correctly and initiate proper corrective action promptly?
- (9) Does the unit attempt to perform higher echelon maintenance to the detriment of that required in its own echelon?
- (10) Are authorized tools on hand, or on order, and in serviceable condition?
- (11) Are unserviceable tools turned in?
- (12) Are air compressors and auxiliary engines properly serviced and maintained?
- (13) Are lubricants properly stored, identified and secured from contamination?
- (14) Are repair parts utilized discriminately as substantiated by the condition of parts which have been replaced?
- (15) Is welding and cutting equipment properly maintained?
- (16) Is training of maintenance personnel adequate?
- (17) Does the unit maintain a preventive maintenance roster?
- (18) Are all vehicles, auxiliary engines, and trailers entered on the roster?
- (19) Are all vehicles scheduled for preventive maintenance services indicated by U.S. Army registration number?
- (20) Are all entries for scheduled services made in pencil on advance basis and inked over when preventive main-

- Score (percent)
- tenance service is completed?.....
- (21) Are the proper symbols or letters used in posting the preventive maintenance roster?.....
- (22) Are the preventive maintenance services properly distributed throughout the month?.....
- (23) Are all forms on hand or on requisition that are needed to properly implement the Army system of maintenance?.....
- (24) Are vehicle and equipment operational records properly filled out?.....
- (25) Is the proper form used for preventive maintenance checks and services? Are these forms retained for the required period?.....
- (26) Are all vehicles dispatched entered on the organizational control record of equipment? Are the appropriate entries made in each column of the record?.....
- (27) Do all drivers have the required U.S. Government operator's identification card? Are these cards properly made out?.....
- (28) Does the equipment log book cover each vehicle?.....
- (29) Are all the authorized publications on requisition or on hand and available for ready reference?.....
- (30) Are required maintenance services up to date?.....
- (31) Does the maintenance shop maintain an equipment modification record?.....
- (32) Is the ordnance section of the organization and/or installation property book properly maintained and up to date?.....
- (33) Do registration numbers of vehicles, serial numbers of

- Score (percent)
- other major items, and quantities of all major items actually on hand agree with those in organizational property book?....
- (34) Do quantities of major items shown as authorized in organizational property book agree with appropriate TOE, TA, or other competent authorizations?....
- (35) Are invalidated property issue slips maintained in a suspense file until validated copies are received from issuing agency?.....
- (36) Are exchange tags in use for repair parts?.....
- (37) Does quantity of repair parts on hand exceed authorized allowances?....
- (38) Is the interchangeability of repair parts employed where possible?.....
- (39) Are repair parts properly stored, tagged, and preserved?.....
- (40) Are used repair parts accounted for by major item registration or serial number?.....
- (41) Are stock number changes posted to date in supply records and catalogs?.....
- (42) Have parts required for equipment out of commission been requested?.....
- (43) Is followup made on outstanding requests for repair parts?.....
- (44) Are all required supply publications on hand?.....
- (45) Is strict supply economy practiced in the use of parts and supplies?.....
- (46) Are supply personnel adequately trained in use of supply publications procedures?.....
- (47) Are unserviceable recoverable parts and assemblies

Score (percent)

Score (percent)

promptly returned to supporting ordnance unit?.....

- (48) Is a jacket file of hand receipts maintained for property loaned to another unit, organization, activity, or individual?.....

c. Vehicle Inspection.

- (1) Is the general appearance of the vehicle satisfactory?.....
- (2) Are registration and unit markings in accordance with current directives?.....
- (3) Are engine compartments clean?.....
- (4) Are cab compartments clean?.....
- (5) Is cargo space clean?.....
- (6) Is vehicle free of rust?.....
- (7) Are door glasses present, unbroken, and clean?.....
- (8) Do door glass regulators operate properly?.....
- (9) Do door latches operate properly?.....
- (10) Do lights operate properly?.....
- (11) Is condition of canvas, upholstery, and fastenings satisfactory?.....
- (12) Are footbrakes adjusted for proper free travel?.....
- (13) Are handbrakes adjusted properly?.....
- (14) Is battery electrolyte at proper level?.....
- (15) Is engine oil clean and at proper level?.....
- (16) Is cooling system filled to proper level?.....
- (17) Is there a copy of the operator's reporting form for a

motor vehicle accident in each vehicle?.....

- (18) Is there an accident identification card in each vehicle?.....
- (19) Are all on-equipment material (OEM) tools present and in good condition?.....
- (20) Does driver seem adequately trained?.....
- (21) Is driver properly licensed?.....
- (22) Is driver interested in his job?.....
- (23) Is there a copy of the current technical manual and lubrication order in each vehicle?.....

3.42 Safe Operating Distances Between Vehicles

The chart below shows average values which may be used in determining safe gaps between vehicles at various speeds on average hardsurfaced roads. Since well-trained drivers can reduce the distance travelled during the perception and reaction periods, the planner should consider the physical condition and state of training of drivers for a particular operation, keeping in mind that rain, snow, or ice present special conditions. Braking distances are based on the assumption that the vehicles are loaded and have good brakes, tires, and traction. Total distances have been determined from the standpoint of safety only; the tactical situation may require larger or smaller gaps. In the absence of definite information, the following rule-of-thumb method may be used to determine the gap between vehicles in a convoy: speedometer reading (mph) $\times$ 2 = gap in yards, or, speedometer reading (kmph) $\times$ 1.2 = gap in meters. (This method should be used only for speeds indicated by asterisks.)

Speed			Average distance required for stopping								
mph	kmph	ft/sec	Perception		Reaction		Braking		Total ¹		
			Feet	Meters	Feet	Meters	Feet	Meters	Feet	Yards	Meters
Passenger vehicles ²											
20*	32.2	29.3	22	6.7	22	6.7	25	7.6	69	23	21.0
25*	40.3	36.7	28	8.5	28	8.5	35	10.7	91	30	27.7
30*	48.3	44.0	33	10.0	33	10.0	48	14.6	114	38	34.6
35*	56.3	51.3	39	11.9	39	11.9	67	20.4	145	48	44.2

¹See footnotes at end of chart.

Speed			Average distance required for stopping								
mph	kmph	ft/sec	Perception		Reaction		Braking		Total ¹		
			Feet	Meters	Feet	Meters	Feet	Meters	Feet	Yards	Meters

Passenger vehicles²—Continued

40*	64.4	58.7	44	13.4	44	13.4	90	27.4	178	59	54.2
45*	72.4	66.0	50	15.3	50	15.3	117	35.7	217	73	66.3
50*	80.5	73.4	55	16.8	55	16.8	148	45.2	258	86	78.8
55	88.5	80.7	61	18.6	61	18.6	185	56.4	307	102	93.6
60	96.6	88.0	66	20.1	66	20.1	228	69.6	360	120	109.8
65	104.6	95.4	72	21.9	72	21.9	275	83.9	419	140	127.7
70	112.6	102.7	77	23.5	77	23.5	332	102.5	486	162	149.5

Single-unit vehicles with gross weight less than 10,000 pounds

20*	32.2	29.3	22	6.7	22	6.7	30	9.2	74	25	22.6
25*	40.3	36.7	28	8.5	28	8.5	42	12.8	98	33	29.8
30*	48.3	44.0	33	10.0	33	10.0	58	17.7	124	41	37.7
35*	56.3	51.3	39	11.9	39	11.9	80	24.4	158	53	48.2
40*	64.4	58.7	44	13.4	44	13.4	106	31.4	194	65	58.2
45*	72.4	66.0	50	15.3	50	15.3	138	42.1	238	79	72.7
50	80.5	73.4	55	16.8	55	16.8	177	54.0	287	96	87.6
55	88.5	80.7	61	18.6	61	18.6	222	67.5	344	115	104.7
60	96.6	88.0	66	20.1	66	20.1	273	83.3	405	135	123.5

Single-unit, 2-axle vehicles with gross weight of 10,000 pounds or more

20*	32.2	29.3	22	6.7	22	6.7	40	12.2	84	28	25.6
25*	40.3	36.7	28	8.5	28	8.5	64	19.5	120	40	36.5
30	48.3	44.0	33	10.0	33	10.0	92	28.0	158	53	48.0
35	56.3	51.3	39	11.9	39	11.9	126	38.4	204	68	62.2
40	64.4	58.7	44	13.4	44	13.4	165	50.3	253	84	77.1
45	72.4	66.0	50	15.3	50	15.3	208	63.4	308	103	94.0
50	80.5	73.4	55	16.8	55	16.8	256	78.1	366	122	111.7
55	88.5	80.7	61	18.6	61	18.6	310	94.5	432	144	131.7
60	96.6	88.0	66	20.1	66	20.1	372	113.5	504	168	153.7

Single-unit vehicles with more than 2 axles and combinations of vehicles (truck tractor, semitrailer, and trailer) with gross weight of 10,000 pounds or more

20*	32.2	29.3	22	6.7	22	6.7	50	15.3	94	32	28.7
25	40.3	36.7	28	8.5	28	8.5	80	24.4	136	45	41.4
30	48.3	44.0	33	10.0	33	10.0	115	35.1	181	60	55.1
35	56.3	51.3	39	11.9	39	11.9	157	47.9	235	78	71.7
40	64.4	58.7	44	13.4	44	13.4	205	62.5	293	98	89.8
45	72.4	66.0	50	15.3	50	15.3	260	79.3	360	120	109.9
50	80.5	73.4	55	16.8	55	16.8	320	97.6	430	143	131.2
55	88.5	80.7	61	18.6	61	18.6	388	118.3	510	170	155.5
60	96.6	88.0	66	20.1	66	20.1	465	141.9	597	199	182.1

¹ Add 30 feet, 10 yards, or 9 meters to each total stopping distance shown when determining actual gap to use between vehicles.

² Does not include buses. For this type of passenger-carrying vehicle, select figures from an applicable section in the remainder of the chart.

Section V. MISCELLANEOUS

3.43 Anchoring Methods

(fig. 3.25)

a. Holdfasts. Natural anchorage should be used whenever possible. Sound wooden pickets, 3 inches in diameter and driven at least 3 feet into dry, undisturbed earth, should stand the following pulls:

Picket	Pounds
Single.....	700
1-1 holdfast combination.....	1,400
1-1-1 holdfast combination.....	1,800
2-1 holdfast combination.....	2,000
3-2-1 holdfast combination.....	4,000

For wet earth, the holding power should be multiplied by the following factors:

Clay and gravel mixture.....	0.9
River clay or sand.....	0.5

b. Deadman. The deadman is a log, railroad tie, or similar object sunk into the ground in such a manner as to afford anchorage for a line. The holding power of a deadman depends upon the bearing area and holding power of the earth. To determine the necessary bearing surface, divide the total stress by the values given in the table below for the depth and cable inclination selected.

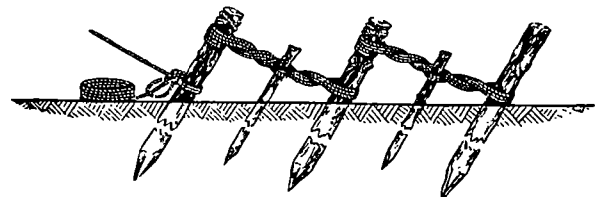
Mean depth of deadman in ordinary earth	Inclination of pull (vertical to horizontal) and safe resistance in pounds per square foot				
	Vertical	1 to 1	1 to 2	1 to 3	1 to 4
3 feet.....	600	950	1,300	1,450	1,500
4 feet.....	1,050	1,750	2,200	2,600	2,700
5 feet.....	1,700	2,800	3,600	4,000	4,100
6 feet.....	2,400	3,800	5,100	5,800	6,000
7 feet.....	3,200	5,100	7,000	8,000	8,400

c. Installation of Deadman. To obtain the best results when installing a deadman, the following procedure should be used:

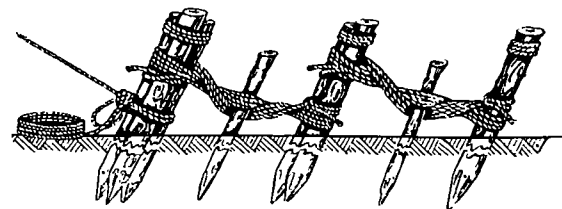
- (1) *Position.* The best position for the deadman is behind a natural crest or mound where as much surface of undisturbed earth as possible may be used. It should be placed far enough away from the vehicle being winched or towed so that it will not interfere when the vehicle clears the obstacle. If the deadman is too close to the vehicle, an upward pull may cause the anchorage to become dislodged.
- (2) *Digging.* Dig a trench deep enough to place the top of the deadman a foot or so below the ground surface, and long and wide enough to hold the deadman.

Undercut the bank in the direction of pull at an angle of about 15° from the vertical. Clear the bottom of the hole at a right angle to this bank. To help strengthen the top edge of the hole in the direction of pull, drive two stakes on each side of the cable at a slightly greater angle to the vertical than the angle made by the bank and flush with the slanted bank near the top. Cut a trench for the cable from the hole through the crest of the hill or mound. This should be slightly deeper than the bottom of the hole at the beginning and should continue out in an ascending slope.

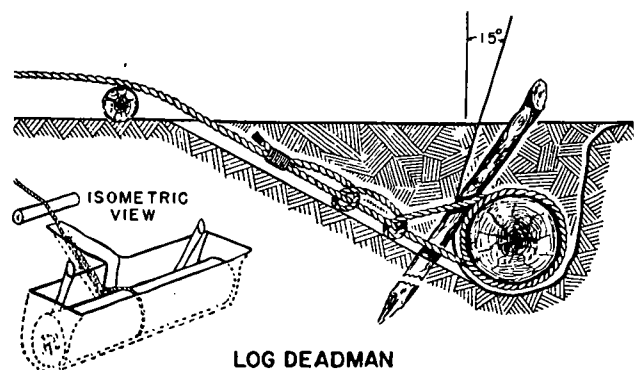
- (3) *Cable attachment.* Attach the cable or chain so that the largest area of the deadman is against the forward bank, and so that any tendency of the deadman to rotate acts downward and not upward.



PICKET HOLDFAST



3-2-1 COMBINATION PICKET HOLDFAST



LOG DEADMAN

Figure 3.25. Picket holdfast and deadman.

3.44 Improvised, Unmounted A-Frame

(fig. 3.26)

An improvised A-frame is a field expedient that provides both a lift and a tow. It is useful for lifting a vehicle out of or over a ditch or hole, and for recovering a badly mired heavy vehicle. It can be made with 2 poles, approximately 12 feet long, and chains, cables, or ropes. The chains are used for lashing the poles together and for towlines. The poles are locked together to form a shears. The legs of the shears are placed in two holes that are dug about 6 inches deep and 6 feet apart; a line is strung across the top of the A-frame between the power source and the vehicle to be moved. The legs of the A-frame must be placed for enough away from the vehicle that is to be moved to keep them from damaging it when it is lifted up and forward. After the front wheels have been lifted out of the ditch, the vehicle must be moved slightly forward and the ditch filled or bridged to allow the rear wheels to cross.

3.45 Winch

a. Using the Winch.

- (1) When used properly, the winch installed on Army vehicles furnishes great lifting and pulling power. Improper use or careless handling, however, results in inefficient performance and possible breakdown of the winch mechanism.
- (2) A vehicle may be taken across an obstacle with the assistance of its own winch by attaching the winch cable to a deadman or tree. The power of the drive wheels should be used whenever possible to assist the winch. Transmission gears should be so selected that the speed of the vehicle's wheels as they move over the ground will be the same as that of the winch cable as it is wound on the winch drum.
- (3) After the vehicle with winch has crossed an obstacle with the assistance of its own winch, it may be used to help other vehicles without winches over the obstacle by either straight towing or winching operations. The winch cable may be extended and attached to the other vehi-

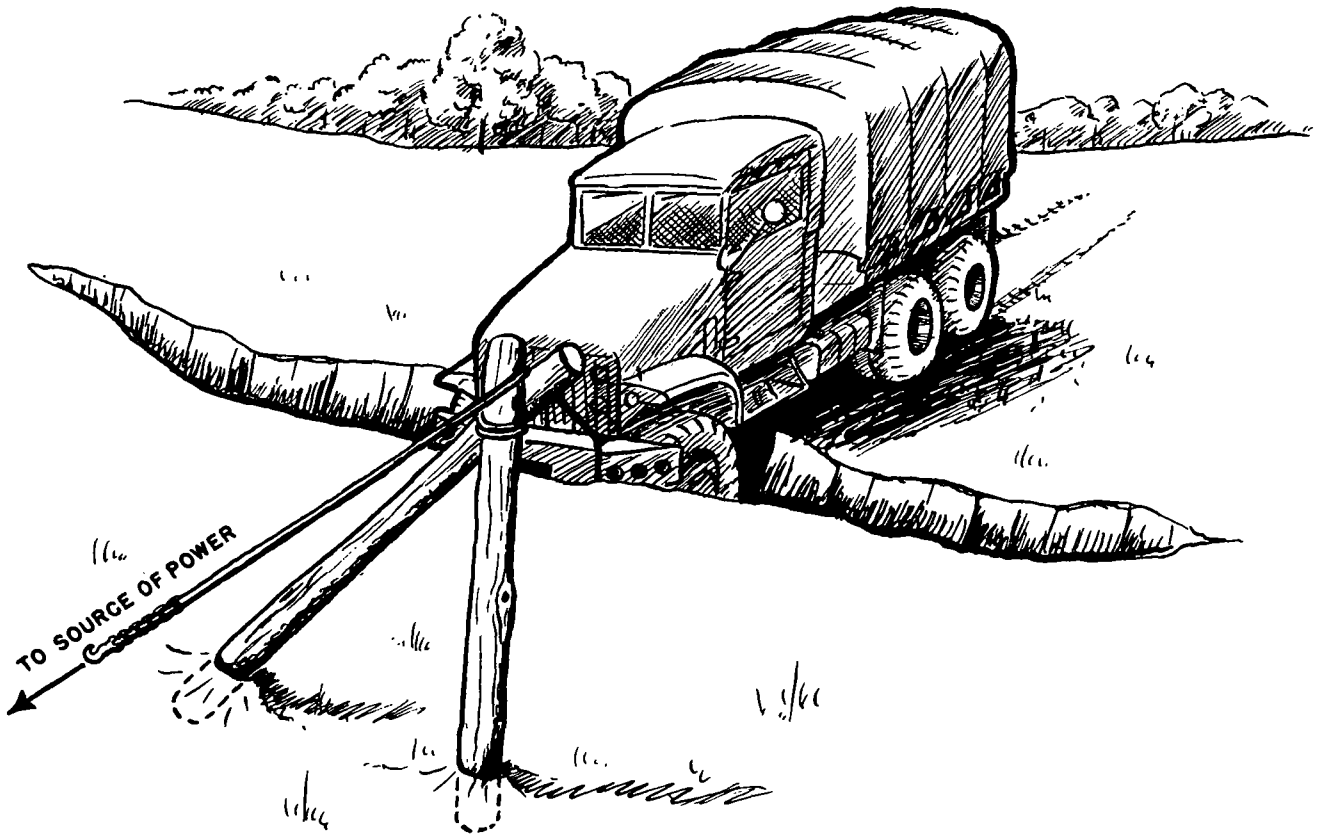


Figure 3.26. A-frame.

cle, the winch mechanism locked, and the truck used as a towing vehicle; or the winch truck may be halted and blocked, and the winch alone used.

- (4) When pulling a vehicle with the winch of another, the towed vehicle should assist with its maximum traction. The best power combination generally results if the winch is operated in the highest gear that will give sufficient power and the truck being winched is pulling in lowest gear.
- (5) When the winch is used on a difficult pull, the winch truck may be held in place by using the brakes and wheel blocks, or by anchoring to a tree or deadman. When the load is not too heavy, traction devices will assist in holding the vehicle in place. A snatch block may be used to increase the mechanical advantage of the winch when pulls are too heavy for the winch alone (fig. 3.27).
- (6) Overturned vehicles cannot always be righted by manpower alone. When necessary, a rigging similar to that shown in figure 3.28 may be used. Parking brakes on the overturned vehicle should be applied before the vehicle is righted. Any towing or winching method may be used to pull on the rope. A holding bridle, placed opposite to the bridle shown in the figure, should be used to prevent the vehicle from being damaged by settling too rapidly. Also, to prevent damage to bridles and the body of the

vehicle, padding (rags and/or small boards) should be used between points of contact.

b. Safety Precautions.

- (1) Certain precautions are necessary in the proper use of the winch cable. Whenever the winch cable is slipped over abrasive surfaces (concrete, asphalt, etc.), it should be protected by placing pieces of wood under it. Power must be applied to the cable gradually. Kinks and twists must always be removed. Cables should not be tied in knots, except for emergency repair. They should not be rigged around an angle in such a manner as to bend them. Vehicles with metal tires should not be permitted to run over the cable.
- (2) Most winches have a shear pin which is designed to break off under any strain which might snap the cable. Nevertheless, when a steel cable is tightened, it may break and snap back with enough force to kill or seriously injure a man. Personnel should stand clear before the cable is tightened. Makeshift shear pins should not be used.
- (3) The cable should be wound evenly on the drum when in use under load and when being rewound after use. To wind the cable evenly, at least a light load is necessary to prevent kinking. Otherwise, the cable may become tangled or damaged, resulting in sharp burrs which can be caused serious injury.
- (4) Personnel handling winch cables should

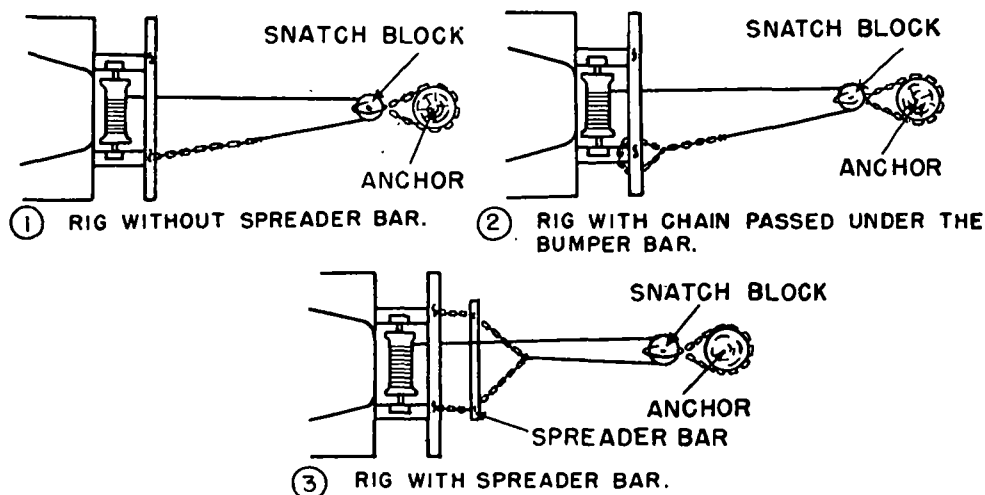


Figure 3.27. Use of winch and snatch block.

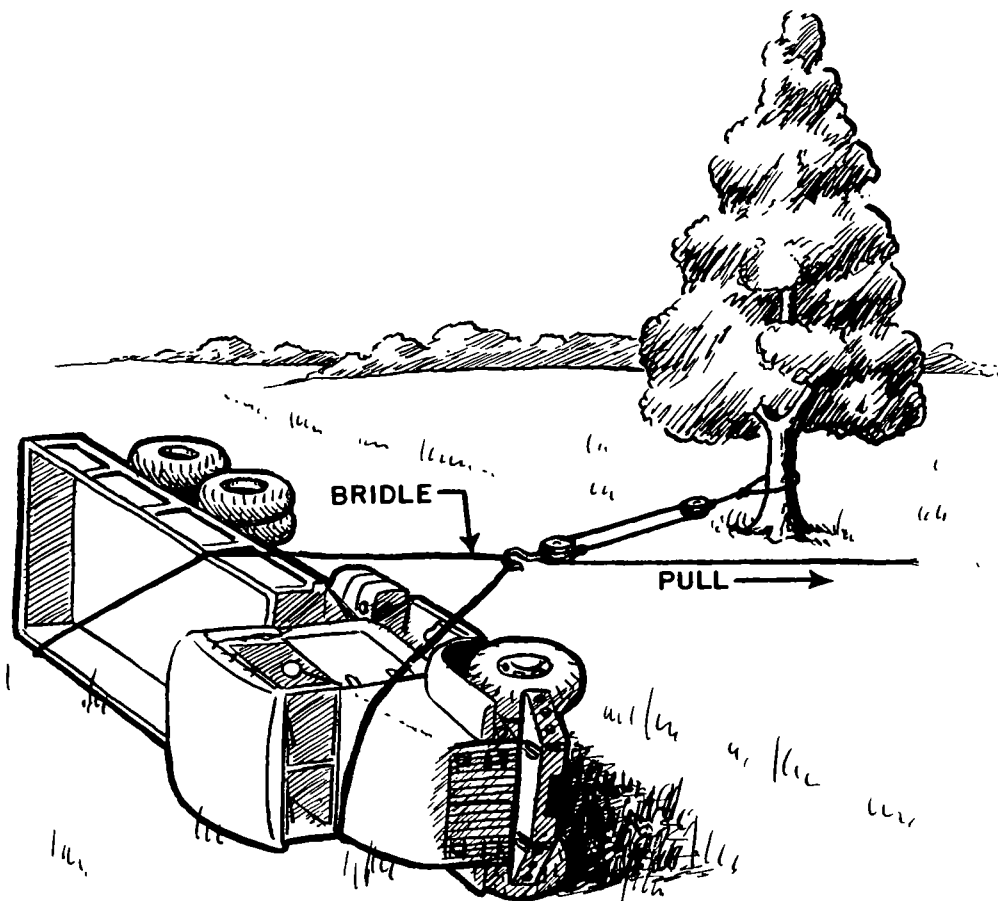


Figure 3.28. Using a winch to right an overturned vehicle.

always wear work gloves, preferably with leather palms, to protect themselves from cuts and scratches caused by broken strands in the cable.

3.46 Chespaling Mats: Expedient Surface for Muddy or Soft Areas

a. Chespaling mats (fig. 3.29) are useful in providing a temporary hard surface in soft sand, mud, or swampy areas. They may be made of small saplings or bamboo rods approximately 6 feet long and about $1\frac{1}{2}$ inches in diameter. The saplings or rods are placed about 3 inches apart and wired together with chicken-wire mesh or smooth wire strands. If saplings are used, they should be kept wet to preserve springiness in the wood and to prevent them from splitting or breaking. A 12-foot mat of this type weighs about 75 pounds.

b. To construct a chespaling road, two mats are laid lengthwise with a 1-foot overlap in the center.

If more mats are added, 1-foot overlap is made on the ends. Pickets may be used to hold the mats down on curves. A mat road of this type should remain serviceable for 3 to 4 months, depending upon weather conditions and the condition of the surface over which it is laid. Approximately 1,500 vehicles may pass over such a road before replacement is needed.

c. Other types of expedient road surfaces for use in soft areas (swamp or snow) are shown in FM 31-70 and TM 5-250.

3.47 Truck-Mounted Forklift

The truck-mounted forklift is particularly suitable for transferring palletized cargo and fuel drums. To mount the forklift truck, bolt it to the rear of the bed of a 6×6 truck (fig. 3.30). Place a counterweight of about 750 pounds at the forward end of the cargo floor. Remove the finger lift of the forklift truck and install an overhead 5-foot arm with a hook at its outer end.

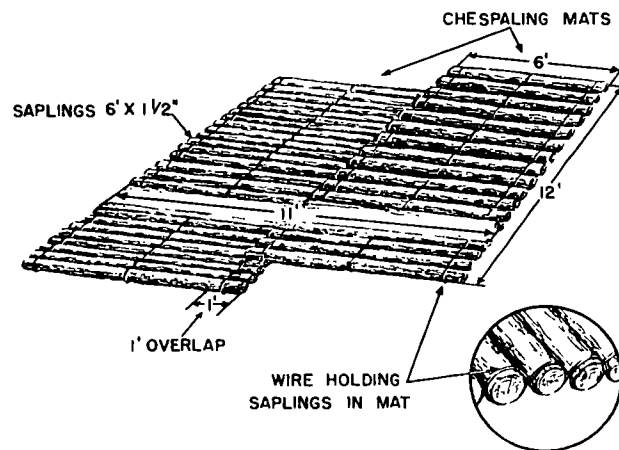


Figure 3.29. Chespaling mats.

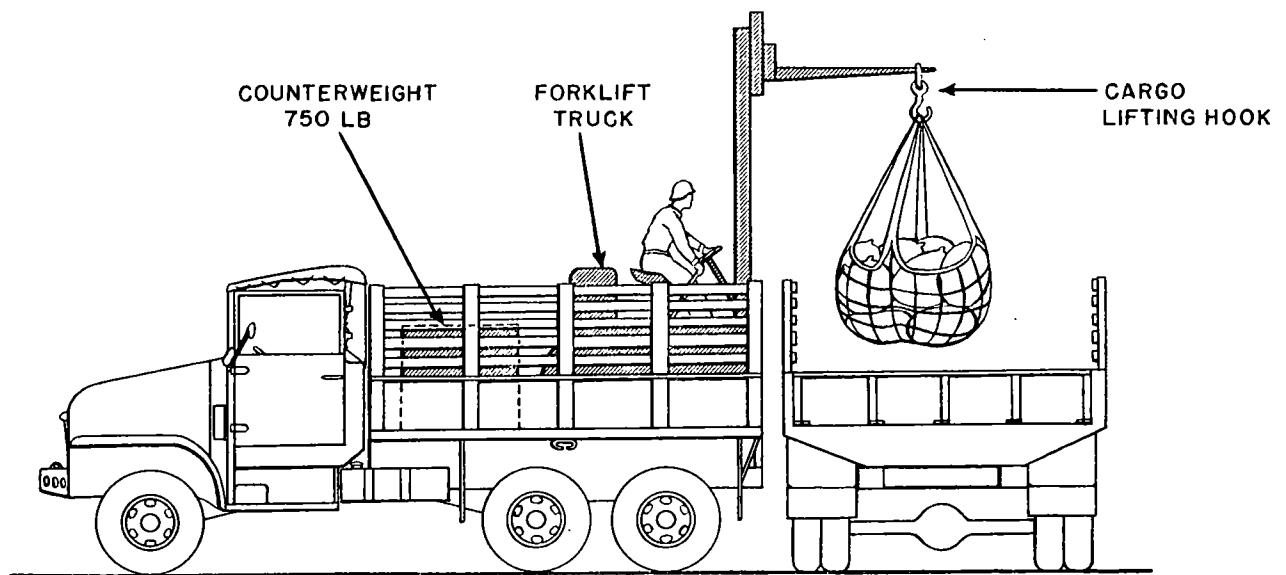


Figure 3.30. Forklift mounted on 6 x 6 truck.

3.48 Weights, Volume, and Conversion Factors for Packaged and Bulk Petroleum Products

Product	Packaging	Weight (lb)	Cubic ft		Conversion factors		Gallons per			Bbl ¹ per LT	Packages per			Capacity of vehicles for carrying filled containers ²									
			Actual	Plan- ning factor	Gal. to lb	Lb to gal.	ST	LT	MT		ST	LT	MT	Trailer		Truck			Semitrailer				
														1- ton	1½- ton	1½- ton	2½- ton	Cargo 5-ton	10- ton	12- ton	25- ton		
Aviation gasoline	Bulk				5.90	.169	339	380		9.04													
	55-gal. drum ³	373	9.03	11	6.91	.145	289	324	188		5.36	6	3.48	5	8	8	13	26	53	64	134		
	55-gal. drum ⁴	389	8.8	11	7.20	.139	278	311	193		5.14	5.76	3.57	5	7	7	12	25	51	62	128		
	55-gal. drum ⁵	364	9.2	11	6.90	.145	290	325	181		5.49	6.15	3.42	5	8	8	13	27	51	66	137		
	5-gal. can ⁶	40.5	.81	1	8.0	.125	250	280	200		49.4	55.3	40.0	49	74	74	124	248	495	594	1,239		
91A gasoline	Bulk				6.11	.164	327	367		8.73													
	55-gal. drum ³	384	9.03	11	7.11	.141	281	315	188		5.21	5.83	3.48	5	7	7	13	26	52	62	130		
	55-gal. drum ⁴	400	8.8	11	7.41	.135	270	302	193		5.0	5.60	3.57	5	7	7	12	25	50	60	125		
	55-gal. drum ⁵	376	9.2	11	7.09	.141	282	316	181		5.32	5.96	3.42	5	8	8	13	26	53	64	133		
	5-gal. can ⁶	41.6	.81	1	8.32	.120	240	269	200		48.1	53.8	40.0	48	72	72	120	240	480	576	1,200		
Kerosene	Bulk				6.80	.147	294	329		7.84													
	55-gal. drum ³	421	9.03	11	7.80	.128	256	287	188		4.75	5.32	3.48	4	7	7	12	23	47	57	119		
	55-gal. drum ⁴	437	8.8	11	8.09	.124	247	277	193		4.58	5.13	3.57	4	6	6	11	22	46	55	114		
	55-gal. drum ⁵	351	9.2	11	6.62	.151	302	338	181		5.70	6.38	3.42	5	8	8	14	28	57	68	142		
	5-gal. can ⁶	45	.81	1	9.0	.111	222	249	200		44.4	49.8	40.0	44	66	66	111	222	445	534	1,110		
Diesel fuel	Bulk				6.99	.145	286	321		7.63													
	55-gal. drum ³	432	9.03	11	8.0	.125	250	280	188		4.63	5.19	3.48	4	6	6	11	23	46	55	116		
	55-gal. drum ⁴	448	8.8	11	8.30	.120	241	270	193		4.46	5.00	3.57	4	6	6	11	22	45	53	112		
	55-gal. drum ⁵	430	9.2	11	8.11	.123	247	276	181		4.65	5.21	3.42	4	7	7	11	23	46	55	116		
	5-gal. can ⁶	46	.81	1	9.20	.109	317	244	200		43.5	48.7	40.0	43	65	65	109	217	436	522	1,090		

Lubricating oils	Bulk				7.60	.132	263	295		7.02											
	55-gal. drum ³	472	9.03	11	8.58	.117	233	261	191		4.24	4.75	3.48	4	6	6	10	21	42	51	106
	55-gal. drum ⁴	488	8.8	11	8.87	.113	226	253	196		4.10	4.59	3.57	4	6	6	10	20	41	49	102
	55-gal. drum ⁵	462	9.2	11	8.56	.117	234	262	185		4.33	4.85	3.42	4	6	6	10	21	43	52	108
	5-gal. can ⁶	49	0.81	1	9.80	.102	204	229	181		40.8	45.7	40.0	40	61	61	102	204	410	489	1,020
	Case of 1-qt cans (12/ case)	35	.88	1							58.0	64.9	40	57	85	85	143	286	572	687	1,430
	Case of 1-qt cans (24/ case)	60	1.6	2							33.4	37.3	20	33	50	50	83	166	333	400	835
	Case of 5-qt cans (6/ case)	77	1.9	2							26.0	29.1	20	26	39	39	65	130	260	312	660
Greases	25-lb pail	29	.95	1							69.0	77.2	40.0	69	103	103	173	345	692	827	1,720
	5-lb can (6/case)	44	1.1	2							45.4	50.9	20.0	45	68	68	114	227	455	545	1,140

¹ For ocean shipping, storage, and pipeline computations, bulk petroleum products usually are measured in barrels of 42 gallons each instead of 55 gallons.

² Based upon authorized off-highway loads in short tons. When overloads are authorized, these quantities may be increased to the cubic capacity of the vehicle or to 100 percent overweight, whichever limit is reached first.

³ 18-gage standard, weighs 54 pounds empty, holds 54 gallons of light products and 55 gallons of heavy products. Federal Specification PPP-D-729, Amendment 1.

⁴ 16-gage standard, weighs 70 pounds empty, holds 54 gallons of light products and 55 gallons of heavy products. Federal Specification PPP-D-729, Amendment 1.

⁵ 18-gage limited standard, weighs 52 pounds empty, holds 53 gallons of light products and 54 gallons of heavy products. Federal Specification PPP-D-729.

⁶ For planning purposes, weight of gasoline may be taken as 42 pounds and weight of lubricating oil for engines as 50 pounds per 5-gallon can, including weight of can. An empty 5-gallon can weighs approximately 11 pounds.

3.49 Volume of Barracks Bags

Barracks bags packed to capacity average 4.4 cubic feet. The following capacities can be used for planning purposes. Quantities are based upon cargo space of vehicles, and can be increased by loading above sideboards for vehicles without closed top. Figures are based upon the assumption that the bags do not average over 50 pounds each. Should this weight be exceeded, appropriate adjustments must be made.

Vehicle	Body cargo space (cu ft)	No. barracks bags
Truck:		
1½-ton, pickup, 4 × 2, Chev..	37	8
¾-ton, cargo, M37.....	160	30
1½-ton, cargo, 4 × 4, Chev..	258	60
2½-ton, 6 × 6, LWB, M36..	630	100
2½-ton, 6 × 6, M135.....	408	87
2½-ton, 6 × 6, COE, 15 ft..	475	100
2½-ton, 6 × 6, M35.....	456	99
2½-ton, 6 × 6, COE, 17 ft..	540	100
5-ton, 6 × 6, cargo, M54....	515	112

Vehicle	Body cargo space (cu ft)	No. barracks bags
Trailer:		
¼-ton, 2-wheel, M100.....	28	6
¾-ton, cargo, M101.....	175	30
1-ton, cargo, 2-wheel.....	113	20
1½-ton, cargo, M104.....	283	59
Semitrailer:		
5-ton, S&P, 2-wheel.....	515	112
6-ton, van, 2-wheel, MGSW4	1.096	240
10-ton, S&P, 2-wheel.....	730	161
12-ton, M127.....	830	184

3.50 Vehicle Size and Weight Limits by States

The chart below may be used as a planning guide. Size and weight limits are changed periodically in the various states as a result of road and bridge construction. Planners must check with local military and/or civilian agencies to verify local limits and methods of clearance or exemption before putting vehicles on the road.

State	Size restrictions							Gross weight limits (pounds)		
	Width (inches)	Height (inches)	Length (feet)			Number of tlr (str = ¼ tlr)	Min tandem axle spacing	Per inch of tire width	In thousands	
			Single unit	Tractor str	Other combi- nations				Per axle	Per tandem axle, 4 feet apart
Alabama ^{a h e}	96	d 150	e 35	50	(i)	½	40	(s)	18	36
Alaska	96	156	35	60	60	2	40	500	18	32
Arizona ^h	102	162	40	65	65	1½	40	(s)	18	32
Arkansas ^h	96	162	e 35	50	50	(i)	40	(s)	18	32
California ^h	j 96	162	k e 35	60	60	(i)	(s)	s 1; m 600	18	32
Colorado ^e	n 96	150	k e 35	60	60	2	40	(i)	o 18; p 16	36
Connecticut ^a	102	150	45	45	(i)	½	(s)	s 1; m 800	22.4	36
Delaware ^h	96	d 150	e 35	50	60	1½	48	700	20	36
District of Columbia ^{b h}	96	150	35	50	50	1 or ½	40	(s)	22	38
Florida ^h	96	d 150	k 40	50	50	1 or ½	40	550	20	40
Georgia	96	162	o q 39.5	48	48	1 or ½	40	(i)	o q 20.3 p q 16	q 40.6
Hawaii	108	156	40	55	65		42		24	40
Idaho ^h	n 96	168	r 35	60	65	1½	(s)	s 800	18	32
Illinois ^t	96	162	42	50	50	1½	40	800	18	32
Indiana	96	162	e 36	50	50	1½	40	800	18	32
Iowa ^{a h}	96	150	k e 35	45	(i)	½	40	(i)	18	32
Kansas ^u	n 96	150	k e 35	50	50	1 or ½	40	(i)	o 18; p 16	32
Kentucky ^{v a}	96	150	35	45	(i)	½	42	600	18	36
Louisiana	96	d 150	k e 35	50	60	1 or ½	40	450	o 18; p 16	32
Maine ^h	96	150	45	45	45	1 or ½	48	600	w 22	32
Maryland ^e	96	d 150	55	55	55	(i)	(s)	(s)	22.4	40
Massachusetts ^{h a}	n 96	(i)	v 35	45	(s)	1 or ½	(s)	800	22.4	36
Michigan	96	d 150	e 35	55	55	1½	42	700	l 18; n 16	x 26
Minnesota ^h	n 96	d 150	40	45	45	1 or ½	i 40	(i)	l 18; m 10.8	28
Mississippi ^{h y}	96	d 150	k e 35	45	45	1 or ½	40		o 18; p 16	x 28.6
Missouri ^h	96	150	k e 35	45	45	(i)	40	600	o 18; p 16	32
Montana ^h	n 96	162	e 35	60	60	1 or ½	40	(s)	18	32
Nebraska ^h	96	150	k e 35	50	50	1 or ½	40	(i)	18	32
Nevada ^h	96	(i)	(i)	(i)	(i)	(i)	42	600	18	32
New Hampshire ^h	96	162	u 35	45	45	(i)	(s)	600	22.4	s 36
New Jersey	96	162	35	45	50	1 or ½	40	800	aa 22.4	32

State	Size restrictions							Gross weight limits (pounds)		
	Width (inches)	Height (inches)	(Length (feet))			Number of tlr (stlr = ½ tlr)	Min tandem axle spacing	Per inch of tire width	In thousands	
			Single unit	Tractor stlr	Other combi- nations				Per axle	Per tandem axle, 4 feet apart
New Mexico ^b ^b	ⁿ 96	162	40	65	64	1 ½	40	600	21.6	34.3
New York ^c	96	156	^k ^c 35	50	50	1 or ½	46	^l 800; ^m 640	22.4	36
North Carolina ^a ^b	ⁿ 96	^d 150	^k ^c 35	48	48	1 or ½	48	600	^p ^q 19; ^p ^q 17	^q 38
North Dakota ^c	96	150	^k 40	50	50	1 or ½	40	550	18	30
Ohio ^c	96	^d 150	^k ^c 35	50	60	(ⁱ)	(^e)	650	19	^x 24
Oklahoma ^h	96	162	^c 35	50	50	1 or ½	40	650	18	32
Oregon ^b ^b	96	150	35	50	50	1 or ½	40	550	18	32
Pennsylvania	96	^d 150	^k ^a ^c 35	50	50	1 or ½	36	800	22.4	36
Rhode Island	102	150	40	50	50	1 or ½	40	800	22.4	(^e)
South Carolina ^h	96	150	^k 40	50	50	1 or ½	40	(ⁱ)	^o 20; ^p 16	32
South Dakota ^h	96	156	^k ^c 35	50	50	1 or ½	40	600	^o 18; ^p 16	32
Tennessee ^a ^b	96	150	^c 35	45	45	1 or ½	40	(^e)	18	32
Texas ^b	ⁿ 96	162	^c 35	45	50	1 or ½	40	^o 650; ^p 600	^o 18; ^p 16	32
Utah ^b	96	168	45	60	60	2	40	(^e)	^l 18; ^m 13.5	33
Vermont	96	150	50	50	50	1 or ½	40	600	(ⁱ)	(ⁱ)
Virginia ^b	96	^d 150	^c 35	50	50	1 or ½	40	650	18	32
Washington ^h	96	150	^a ^d 35	60	60	1 ½	42	500	18	32
West Virginia ^b	96	^d 150	^k ^c 35	45	45	1 or ½	40	(ⁱ)	18	32
Wisconsin ^b ^c	ⁱ 96	^d 150	^c 35	50	50	1 or ½	40	800	^a ^o 18; ^a ⁱ 12	^q 32
Wyoming ^b	^j 96	162	40	60	60	2	40	(^e)	18	32

^a Full trailers are permitted the same gross weight as other single units with the following exceptions: Alabama, Connecticut, Iowa, Kentucky—full trailers prohibited; Massachusetts—trailer and load limited to 3,000 pounds; Tennessee—trailer and load limited to 3,500 pounds.

^b Solid tires prohibited.

^c States where gross weight is determined by formula.

^d Automobile transporters allowed 13 ½ feet (also covered vans in Washington; baled hay or straw carriers in Maryland; hay, straw, or small-boat carriers in Michigan).

^e Buses of 40 feet may be permitted in Virginia; 42 feet in Delaware; 45 feet in Oklahoma; 45.2 feet in Georgia.

^f Not permitted.

^g Not specified.

^h States where gross weight is determined by table of axle spacing.

ⁱ No restrictions.

^j 104 inches for urban buses.

^k Vehicles over 35 feet in length must have three axles, except buses in Florida and South Carolina.

^l Pneumatic tires.

^m Solid tires.

ⁿ 102-inch buses permitted subject to the following restrictions; Idaho, Montana, and Wyoming—only on highways at least 20 feet wide; New Mexico—only on designated highways; Kansas, Massachusetts, Minnesota, North Carolina, and Texas—only in designated urban areas.

^o Permissible on balloon tires.

^p Permissible on other than balloon tires.

^q Including tolerance.

^r 40-foot, 2-axle vehicles permitted on highways designated by Board of Highway Directors.

^s Graduated according to width.

^t Limits shown are permissible on designated highways; otherwise limited to 16,000 pounds on any 1 axle. Two-axle truck limited to 32,000 pounds under registration law.

^u Buses with 3 axles permitted 40 feet on designated highways, subject to 18,000-pound limit per axle.

^v Limits shown are permissible on designated highways; otherwise limits are: truck height—11 ½ feet, truck length—28 ½ feet; semitrailer combination length—30 feet; gross weight 18,000 pounds.

^w Axles less than 10 feet apart limited to 16,000 pounds per axle.

^x Michigan—32,000 pounds on one set of tandem axles in a combination on designated highways; Mississippi—32,000 pounds on designated highways; Ohio—31,500 pounds on axles spaced over 4 feet but less than 8 feet apart.

^y Gross weight limits shown are permissible on designated highways. On other highways gross weight limits are graduated from 28,650 pounds (axle spacing of 4 feet) to 52,650 pounds (axle spacing of 30 feet or more).

^z Except on three-axle single units.

^{aa} Applies to vehicles registered after March 1, 1950.

^{ab} North Carolina—gross weight limit on most secondary highways is 16,000 pounds for 2 axles and 24,000 pounds for 3 axles.

^{ac} 30-inch tolerance permitted auto-transporter semitrailers.

^{ad} Director of highways may allow 3-axle buses 40 feet on designated highways.

^{ae} Permissible on class A highways.

^{af} Permissible on class B highways.

CHAPTER 4

RAIL

Section I. ORGANIZATION

4.1 Organization of the Transportation Railway Service

(fig. 4.1)

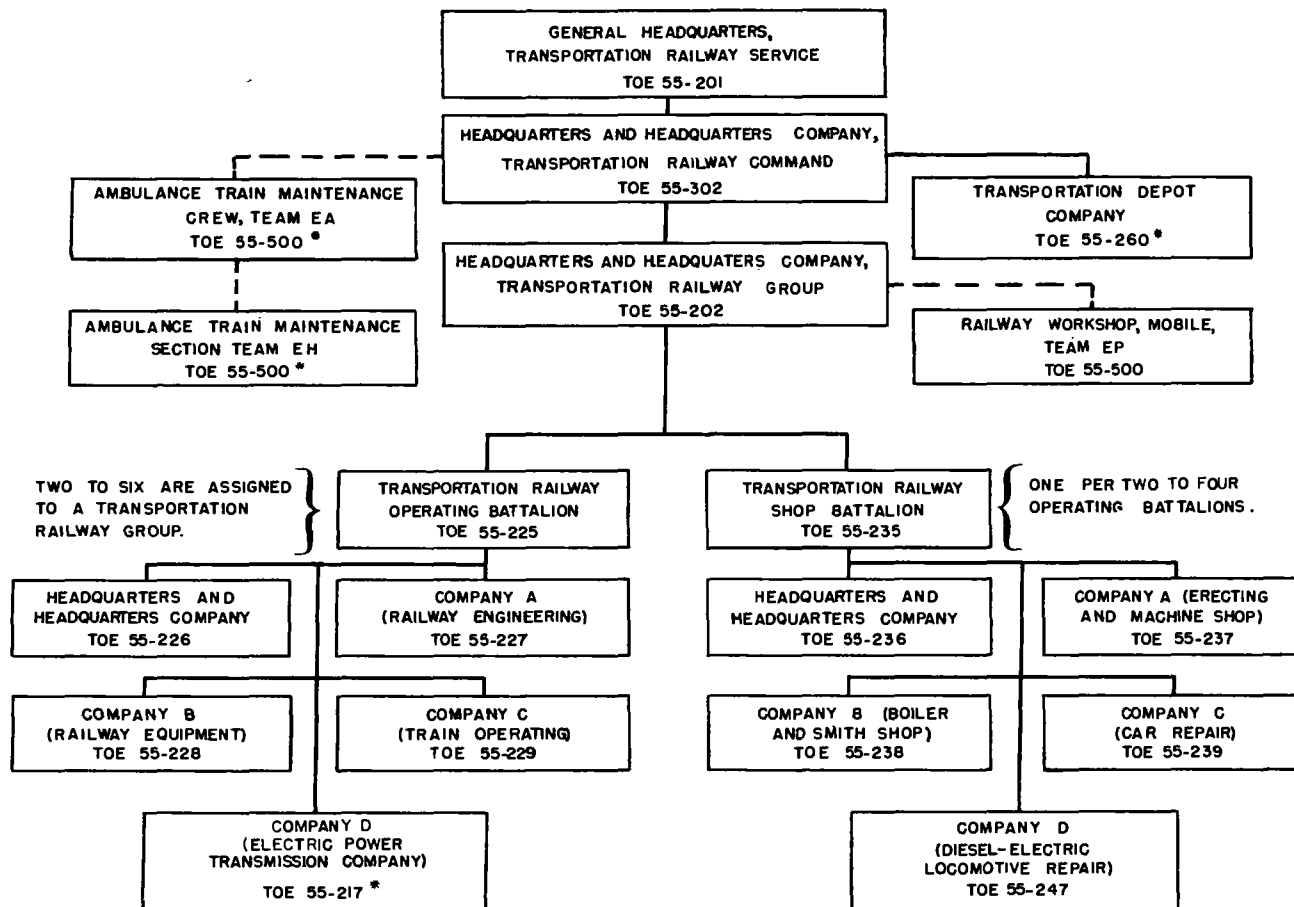
<i>Unit</i>	<i>TOE</i>	<i>Mission and/or capability</i>	<i>Assignment</i>
General headquarters, transportation railway service.	55-201	Provides executive, supervisory, and administrative personnel for overall supervision and direction of the railroads in a theater of operations.	Normally 1 to a theater having 2 or more headquarters companies, transportation railway command.
Headquarters and headquarters company, transportation railway command.	55-302	Commands and supervises 2 or more railway groups. Capable of overall supervision and direction of a large railway system in a theater of operations.	To a theater of operations. It is the highest echelon in the theater if there is no general headquarters, transportation railway service.
Headquarters and headquarters company, transportation railway group.	55-202	Commands and supervises 2 to 6 railway operating battalions and 1 or 2 railway shop battalions, plus attached military police, signal, and other service units. In a theater of limited operations, it may be the highest echelon.	To a headquarters and headquarters company, transportation railway command. If there is no transportation railway command in a theater, the group may operate separately under operational control of the theater transportation officer.
Transportation railway operating battalion.	55-225	Operates and maintains a military railway division in a theater of operations. Can operate 40 steam engines or 20 diesel-electric engines per day in road and yard service over 90 to 150 miles of railroad and can inspect and maintain right-of-way for this mileage. Inspects condition of and performs organizational and field maintenance repairs on approximately 40 locomotives and 800 railroad cars. Performs running inspections of approximately 2,000 railroad cars per day. Also repairs tools and mechanical equipment of all companies in the battalion.	Normally 2 to 6 to a railway group.
Headquarters and headquarters company, transportation railway operating battalion.	55-226	Supervises and coordinates the operations of a railway operating battalion. Provides 1 operating battalion with the necessary supply, administration, and train dispatching services. Distributes rolling stock and locomotives as directed, and operates railway stations and towers.	1 per railway operating battalion.
Company A (railway engineering), transportation railway operating battalion.	55-227	Maintains and repairs approximately 90 to 150 miles of right-of-way, tracks, railway signals, electrical communications, structures, bridges, and buildings located within a railway division.	Organic to railway operating battalion (normally 1 per battalion).
Company B (railway equipment), transportation railway operating battalion.	55-228	Inspects, services, and makes running repairs on approximately 40 locomotives and 800 railway cars. Makes running inspections on 2,000 railway	Organic to railway operating battalion (normally 1 per battalion).

<i>Unit</i>	<i>TOE</i>	<i>Mission and/or capability</i>	<i>Assignment</i>
		cars per day. Repairs tools and mechanical equipment of all companies within the battalion.	
Company C (train operating), transportation railway operating battalion.	55-229	Operates locomotives and trains. Provides train crews to operate 40 locomotives per day over 90 to 150 miles of railroad.	Organic to railway operating battalion (normally 1 per battalion).
Company D (electric power transmission), transportation railway operating battalion.	55-217	Maintains and repairs electric power transmission facilities for train operation on an electrified division of a military railway (200 miles of electrified railway). Can maintain a catenary or third-rail system with substations, but cannot actually generate the required power.	To railway operating battalion.
Transportation railway shop battalion.	55-235	Provides depot maintenance on locomotives, cars, and equipment. Capable of supporting 2 to 4 operating battalions, up to 100 steam locomotives, 200 diesel-electric locomotives, and 2,500 railroad cars.	Normally 1 or 2 to a railway group.
Headquarters and headquarters company, transportation railway shop battalion.	55-236	Commands and furnishes technical supervision and plant maintenance for the railway shop battalion, plus administration, mess, and supply of companies organic to the railway shop battalion.	1 per railway shop battalion.
Company A (erecting and machine shop), transportation railway shop battalion.	55-237	Performs depot maintenance involving erecting and machine shop work for a military railway using steam locomotives and/or diesel-electric locomotives, in support of 100 steam locomotives, 200 diesel-electric locomotives, and 2,500 railway cars.	Organic to railway shop battalion (normally 1 per battalion).
Company B (boiler and smith shop), transportation railway shop battalion.	55-238	Performs boiler and blacksmith repairs to locomotives and rolling stock, in support of 100 steam locomotives, 200 diesel-electric locomotives, and 2,500 railway cars.	Organic to railway shop battalion (normally 1 per battalion).
Company C (car repair), transportation railway shop battalion.	55-239	Performs heavy repairs on freight and passenger cars for 2 to 4 railway operating battalions, in support of 2,500 cars.	Organic to railway shop battalion (normally 1 per battalion).
Company D (diesel-electric locomotive repair), transportation railway shop battalion.	55-247	Performs inspections and depot maintenance and support of 200 diesel-electric locomotive units.	Organic to railway shop battalion (normally 1 per battalion).
Transportation depot company.	55-260	Receives, stores, and issues all transportation items of supply, up to 100 tons per day.	To a logistical command or to a general depot as the transportation section. Normally 1 depot company per 35,000 troops in a theater of operations. May be assigned to a railway command.
Team EA, ambulance train maintenance crew.*	55-500	Performs running repairs on railway cars of 1 ambulance train.	To headquarters and headquarters company, transportation railway command; or to senior transportation railway unit in a theater of operations.

See footnote on page 126.

Unit	TOE	Mission and/or capability	Assignment
Team EH, ambulance train maintenance section.*	55-500	Performs field maintenance repairs on ambulance trains, up to 4 trains.	Same as Team EA, above.
Team EP, railway workshop, mobile.*	55-500	Performs daily field maintenance of 5 steam and 15 diesel-electric locomotives and 100 railway cars in forward areas where stationary facilities are inadequate.	Normally to headquarters and headquarters company, transportation railway group.

* See TOE 55-500 for additional railway service teams.



* ASSIGNED AS REQUIRED.

Figure 4.1. Organization of the transportation railway service.

Section II. EQUIPMENT

4.2 Whyte Classification System of Locomotives

The locomotives described in this section are classified according to the Whyte system, which classifies locomotives according to the arrangement of their wheels. A series of numerals separated by hyphens is used to designate the total number of wheels on the axle of each type of locomotive truck—the front (leading) truck, driving wheel

group, and rear (trailing) truck, respectively. The figures always describe the locomotive's wheels from front to rear; the wheels in the locomotive tender are not counted in the classification. For example, a Whyte classification of 2-8-2 indicates one pair of leading wheels, four pairs of coupled driving wheels, and one pair of trailing wheels. The absence of any of the three types of wheels is always denoted by a zero; thus a 2-8-0 locomotive has no trailing wheels. Diesel loco-

motives may also be classified by this system; figures such as 0-6-6-0 indicate no leading or trailing wheels and two sets of three driving axles each, or a total of 12 driving wheels. The classification commonly used in Europe and other parts of the world, however, classifies a diesel or electric locomotive by letters and figures. A diesel 0-4-4-0 is classified B-B; a 0-6-6-0 is designated C-C, etc.

Idler (those which exert no tractive effect) wheels and leading and trailing wheels are designated with numbers. A single-unit locomotive with two six-wheel trucks in which the center wheel is an idler would be designated as A1A-A1A. An electric locomotive with four-wheel leading and trailing trucks and six driving wheels would be designated 2-C/C-2.

4.3 Characteristics of Railway Equipment

a. Locomotives.

(1) Steam.

Type	Gage (in.)	Weight, loaded (lb)			Tractive force (lb)	Drawbar pull (lb)	Curvature, min radius (ft)	Fuel capacity	Water capacity
		Locomotive	Tender	On drivers					
82-ton, 2-8-0	56½, 60, 63, 66	165,000	133,575	143,000	34,000 (85% boiler pressure)	42,000 (approx.)	231	11-ton coal or 2,000-gal. oil.	7,500-gal. tender
80-ton 0-6-0	56½	160,000	133,575	160,000	40,000	38,400	193	Same as above	Same as above

(2) Diesel-electric.

Type	Gage (in.)	Weight locomotive (lb)	Tractive force (lb)		Horsepower	Curvature, min radius (ft)	Fuel capacity (gal.)
			Starting at 30-percent adhesion	Continuous			
131-ton, 0-6-6-0, domestic and foreign service. ¹	56½	262,000	75,700	(^a) 37,850	1,000	231	
127-ton, 0-6-6-0, domestic and foreign service.	56½	254,000	75,700	(^a) 37,850	1,000	231	
120-ton, 0-4-4-0, domestic service.....	56½	240,000	72,000	35,000 at 10 mph	1,200	193	750
120-ton, single engine, 0-4-4-0, domestic service.	56½	240,000	72,000	34,000 at 8.3 mph	1,000	75	700
120-ton, 0-4-4-0, domestic service.....	56½	240,000	72,000	(^a) 36,000	1,500	150	
120-ton, 0-6-6-0, foreign service.....	56½, 60, 63, 66	240,000	72,000	45,000 at 10 mph	1,600	193	1,600
115-ton, 0-4-4-0, domestic service.....	56½	230,000	69,000	(^a) 34,500	1,000	50	
100-ton, 0-4-4-0, domestic service.....	56½	200,000	59,700	(^a) 29,850	660	50	
80-ton, 0-4-4-0, dual engine, domestic service.	56½	161,000	48,000	21,000 at 5.2 mph	470	75	300 or 400
76-ton, 0-6-6-0, foreign service.....	36, 39¾, 42	152,000	45,000	(^a) 22,500	975	100	
65-ton, 0-4-4-0, domestic service.....	56½	130,000	39,000	(^a) 19,500	400	75	
60-ton, 0-4-4-0, foreign and domestic service.	56½, 60, 63, 66	122,000	36,000	15,680 at 7.28 mph	450	75	500
58-ton, 0-4-4-0, foreign service.....		116,000	36,000	(^a) 18,000	400	75	
48-ton, single engine, 0-4-4-0, foreign service.	36, 39¾, 42	115,000	34,500	15,680 at 7.28 mph	400	75	500

Type	Gage (in.)	Weight locomotive (lb)	Tractive force (lb)		Horse- power	Curvature, min radius (ft)	Fuel capacity (gal.)
			Starting at 30-percent adhesion	Continuous			
45-ton, side-rod drive, 0-4-4-0, domestic service.	56 1/2	90,000	27,000	(a) 13,500	300	50	
45-ton, 0-4-4-0, domestic and foreign service.	-----	90,000	27,000	(a) 13,500	380	75	
44-ton, 0-4-4-0, domestic service.	56 1/2	88,000	26,400	(a) 13,200	380	75	
25-ton, 0-4-0, domestic service.	56 1/2	50,000	15,000	(a) 6,200 at 6.2 mph	150	50	75
25-ton, 0-4-0, foreign service.	42	50,000	15,000	(a) 6,200 at 6.2 mph	150	40	75

* For diesel-electric power, the continuous TE is approximately half of the starting TE.

^b Reduced to 800 if equipped with Clarkson vapor heater.

(3) Gasoline-mechanical and diesel-mechanical.

Type	Gage (in.)	Weight (lb)	Drawbar pull (lb)	Horse- power (total engine)	Curva- ture, min radius (ft)	Fuel capacity (gal.)
10-ton, single engine, 0-4-0, domestic service.	56 1/2	20,000	-----	100	75	30 (diesel)
5-ton, single engine, 0-4-0, foreign and domestic service.	36	11,000	2.7 mph—2,500 12 mph—875	34	20	15 (gasoline)

b. Boxcars.

Type	Gage (in.)	Capacity		Inside			Door dimensions	Tare weight empty (ST)
		(lb)	(cu ft)	Length	Width	Height		
8W, narrow gage, foreign service.	36, 39 3/8, 42	60,000	1,588	34' 5 1/2"	7' 3/4"	6' 4"	7' 10 1/4" wide 6' 1/8" high	13.6
8W, domestic service.	56 1/2	100,000	3,975	40' 6"	9' 2"	10' 6"	6' wide, clear opening 8' high, clear opening	23
8W, broad gage, foreign service.	56 1/2, 60, 63, 66	80,000	2,520	40' 6"	8' 6"	6' 5 5/8"	8' 3 1/4" high 6' 8 3/4" wide	18.5

c. Open-Top Cars.

(1) Flatcars.

Type	Gage (in.)	Nominal capacity (lb)*	Platform length*	Platform width*	Platform height above rail	Tare weight empty (ST)
8W, narrow gage, foreign service.	36, 39 3/8, 42	60,000	34' 8 1/2"	7' 2"	3' 7"	10.9
12W, domestic service.	56 1/2	200,000	54'	10' 6 1/2"	4' 1 1/4"	35
8W, domestic service.	56 1/2	140,000	49' 11 1/2"	10' 3 1/4"	3' 8 1/2"	27
12W, broad gage, foreign service, 80-ton.	56 1/2, 60, 63, 66	160,000	46' 4"	9' 8"	4' 2 7/8"	35.3
12W, domestic service (passenger train service).	56 1/2	200,000	54'	10' 6 1/4"	4' 5 3/8"	
8W, domestic service.	56 1/2	100,000	43' 3"	10' 6"	3' 8"	25.5
8W, broad gage, foreign service.	56 1/2, 60, 63, 66	80,000	40' 9"	8' 7 1/4"	3' 6 15/16"	14.5
8W, broad gage, depressed center, foreign service.	56 1/2, 60, 63, 66	140,000	50' 7"	9' 8"	-----	41.5

* To determine vehicle-carrying capacity of flatcars, use these three columns in conjunction with the information contained in paragraph 3.2. Determine first the number of vehicles by type that will fit on the flatcar bed. Then check their combined weights (including any cargo in the vehicles) against the weight capacity of the car. Either the platform dimensions of the flatcar or its weight-carrying capacity is the controlling factor. Side sills of flatcars must be considered in determining ability to carry tracked vehicles, such as tanks, where the total loaded weight is resting on the outer edge of the car deck.

(2) *Gondolas.*

Type	Gage (in.)	Capacity		Inside dimensions ^a			Tare weight empty (ST)
		(lb)	(cu ft)	Length	Width	Height	
High side, 8W, narrow gage, foreign service..	36, 39 $\frac{3}{8}$, 42	60,000	940	34' 5"	6' 10 $\frac{1}{2}$ "	4'	13
Low side, 8W, narrow gage, foreign service..	36, 39 $\frac{3}{8}$, 42	60,000	356	34' 6"	6' 10 $\frac{1}{2}$ "	1' 6"	12.1
High side, 8W, broad gage, foreign service..	56 $\frac{1}{2}$	80,000	1,680	40'	8' 3 $\frac{3}{4}$ "	4'	18
Low side, 8W, broad gage, foreign service..	56 $\frac{1}{2}$, 60, 63, 66	80,000	500	40' 4 $\frac{1}{2}$ "	8' 3 $\frac{1}{4}$ "	1' 6"	16
Low side, 8W, drop ends, domestic service..	56 $\frac{1}{2}$	100,000	1,184	41' 6"	9' 6 $\frac{1}{8}$ "	3'	23
High side, std gage, domestic service.....	56 $\frac{1}{2}$	100,000	-----	41' 6"	9' 6"	4' 6"	25

(3) *Hopper car.*

Type	Gage (in.)	Nominal capacity (lb)	Inside dimensions		
			Length	Width	Height
8W, domestic service.....	56 $\frac{1}{2}$	100,000	33'	9' 5 $\frac{1}{2}$ "	9' 7"

d. *Tank Cars.*

Type	Gage (in.)	Length over tank heads	Nominal capacity (gal.) ¹	Inside diameter (in.)		Tare weight empty (ST)
				Tank ²	Dome	
Nickel-clad, ICC-103-AW, 8W, domestic service.....	56 $\frac{1}{2}$	31' 11"	7,500	78, approx	45	
ICC-103, ICC-103-W, 8W, domestic service ..	56 $\frac{1}{2}$	34', approx	10,000	87, approx	59 $\frac{3}{8}$, approx	
Caustic soda, ICC-103-W, 8W, domestic service.....	56 $\frac{1}{2}$	34', approx	10,000	88, approx	64	
Petroleum, 8W, narrow gage, foreign service..	36, 38 $\frac{3}{8}$, 42	38' 4 $\frac{1}{8}$ "	6,000	62 $\frac{1}{2}$	54	16
Petroleum, 8W, broad gage, foreign service....	56 $\frac{1}{2}$, 60, 63, 66	38' 5 $\frac{3}{8}$ "	10,000	80 $\frac{3}{4}$	66 $\frac{1}{2}$	19
Nitric acid, ICC-103-W, 8W, domestic service.....	56 $\frac{1}{2}$	33' 7 $\frac{1}{2}$ "	7,800	78, approx	35 $\frac{3}{8}$	23
Phosphorus, ICC-103-W, 8W, domestic service.....	56 $\frac{1}{2}$	34' 8 $\frac{1}{4}$ "	8,000	78, approx	64	
Petroleum, std gage, domestic service.....	56 $\frac{1}{2}$	-----	10,000	-----	-----	

¹ Specific gravity of a liquid should be checked before it is loaded to avoid exceeding weight capacity of car.

² See paragraph 7.28 below for liquid volume in partially filled tank cars.

e. *Refrigerator Cars.*

Type	Gage (in.)	Nominal capacity (lb)	Length inside end lining	Width inside side lining	Ice capacity (lb)	Dimensions of doors
8W, disassembled, foreign service.....	56 $\frac{1}{2}$	80,000	38' 9 $\frac{1}{2}$ "	6' 11"	11,000	4' wide 7' high
8W, disassembled, broad gage, foreign service.	56 $\frac{1}{2}$, 60, 63, 66	80,000	32' $\frac{1}{2}$ "	7' 8", approx	11,000	4' wide 7' high
8W, mechanical, foreign service.....	56 $\frac{1}{2}$, 60, 63, 66	80,000	40' 9", equipment compartment	7' 6", approx	None	6' wide 7' high

f. Special Purpose Cars.

Type	Gage (in.)	Weight (lb)		Over end sills		Height above rail	Remarks
		Light	Loaded	Length	Width		
Car, amb unit, 8W, domestic service.	56½	157,000	167,300	78' 11"	10'	13' 6"	Capacity: 27 patients, 6 corpsmen, 1 nurse, 1 doctor.
Car, kitchen, troop/amb train, 8W, domestic service.	56½	100,160	-----	*54' 2½"	9' 5¾"	13' 6"	Width, side door openings: 6'.
Car, kitchen, dining and storage, amb train, 8W, foreign service.	56½, 60, 63, 66	111,400, avg	-----	63' ¼"	9'	13'	Seat capacity: 24
Car, ward, amb train-----	56½, 60, 63, 66	111,400, avg	-----	63' ¼"	9'	13'	Berth capacity: 30
Car, personnel, amb train---	56½, 60, 63, 66	111,400, avg	-----	63' ¼"	9'	13'	Berth capacity: 15 EM's, 4 doctors, 2 nurses.

* Includes couplers.

g. Cranes.

Type	Gage (in.)	Weight (lb)	Boom length (ft)	Boom height (down)
Wrecking, steam, 75-ton, broad gage, foreign service-----	56½, 60, 63, 66	191,000	25, 2-piece, curved	12' 3¾"
Locomotive, diesel-mechanical, 25-ton, broad gage, domestic and foreign service.	56½, 60, 63, 66	148,000	50, 2-piece, straight	13' 6" max.
Locomotive, diesel-mechanical, 40-ton, broad gage, foreign service.	56½, 60, 63, 66	210,000	50, 2-piece, straight	13' 6" max.
Locomotive, diesel-mechanical, 25-ton, narrow gage, foreign service.	36, 39¾, 42	161,000	40, 2-piece, straight	10' 10"

4.4 Dimensions, Weight, and Capacities of Typical U.S. Freight Cars

There are no standard dimensions for commercial cars. The figures given are for types in common use. The 40-ton stock car comes in many lengths, varying from 35' 7" to 41' 10". All types have similar variations in capacity and dimensions.

Type	Capacity				Weight empty (tons)	Inside dimensions (ft)		
	Tons	Men (8 sq ft per man and equipment)	Animals (horses, mules, oxen—avg. width, 22 inches)	Cubic feet		Length	Width	Height
Automobile-----	40	45	22	3,100	20	40.5	8.5	9
	50	58	27	4,702	25	50.6	9.2	10.1
Baggage-----					45	60	9.1	8
Box-----	30	38	20	2,750	18	36	8.5	9
	40	43	22	3,100	20	40.5	8.5	9
	50	43	22	3,100	24	40.5	8.5	9
Caboose-----					20	27.5	8.2	7
Diner-----					90	78.5	8.5	8.5
Flat-----	40				18	40	9	-----
	50				20	45	9	-----
	70				25	50	9	-----
Gondola-----	50			1,570	22	40	9.9	4
	70			1,920	25	48	10	4
Refrigerator-----	*30			2,570	28	40.5	8.2	7.2

Type	Capacity				Weight empty (tona)	Inside dimensions (ft)		
	Tona	Men (8 sq ft per man and equip-ment)	Animals (horses, mules, oxen—avg. width, 22 inches)	Cubic feet		Length	Width	Height
Stock	^b 40	-----	-----	2,570	30	40.5	8.2	7.5
	30	-----	20	2,625	20	36	8.5	8.5
	40	-----	20	3,003	22	40.6	8.6	8.6
Tank	^c 40	-----	-----	-----	20	33	^e 6.6	-----
	^d 50	-----	-----	-----	24	33	^e 7.2	-----

^a Ice capacity, 4 tona.

^b Ice capacity, 5 tona.

^c 8,000 gal.

^d 10,000 gal.

^e Diameter.

4.5 Capacity of Standard U.S. Passenger Cars

	Day coach ¹	Tourist sleeper	Standard sleeper ²
Length in feet	65-75	65-75	65-80
Number of sections	None	13-16	12-16
Maximum seating:			
2 men to each double seat	60-70	52-64	53-64
3 men to each 2 double seats	45-52	39-48	40-48
Sleeping capacity:			
2 men per berth (maximum)	None	52-64	53-64
3 men per section	None	39-48	36-48
1 man per berth	None	26-32	27-32

¹ Limited number of steel coaches, 70 feet long or over, available.

² Standard sleeper—12 sections and 1 drawing room or 16 sections and no drawing room.

Section III. OPERATIONS

4.6 Planning Requirements

In planning for the most effective use of a rail-way system, detailed information about items *a* through *z* below is essential. FM 55-8 provides additional information on evaluating existing facilities.

- a.* Length of line.
- b.* Condition of roadbed and track.
- c.* Gage of track.
- d.* Single, double, or multiple track.
- e.* Weight of rail.
- f.* Type of ballast and depth.
- g.* Type of ties (if wood, treated or untreated).
- h.* Tie spacing.
- i.* Axle-load limitations (track and bridge).
- j.* Profile of line showing location and length of ruling grade.
- k.* Alinement of lines showing location and length of minimum-radius curves.
- l.* Location and description of bridges and tunnels.
- m.* Location and length of passing tracks.
- n.* Location, type, and quantity of fuel supply.

o. Location, quantity, and quality of water supply.

p. Location and capacity of yards.

q. Location and capacity of car repair shops and enginehouses.

r. Type and availability of motive power (weight in working order, expected working tractive effort, drawbar pull, and age).

s. Type and availability of rolling stock (capacity, dimensions, and age).

t. Climatic and prevailing weather conditions.

u. Diagrams showing minimum structure, maximum unrestricted loading, and equipment gages.

v. Signal system (wire or radio requirements and coordinating responsibilities).

w. Dispatching facilities.

x. Route junctions.

y. Availability of new equipment and repair parts.

z. Local labor resources.

4.7 Outline of Standing Operating Procedure for Rail Movements

a. General. Policies and factors involved in selecting and accomplishing movements via rail.

b. Supply Movements.

- (1) *Releases.* When required, methods of obtaining, formats, dissemination, action required.
- (2) *Routing.* Responsibilities and procedures for determination, coordination, and accomplishment.
- (3) *Diversions and reconsignments.* Authority and initiating procedures for; method of execution.
- (4) *Records and reports.* Responsibilities and methods for the maintenance of specific records; appropriate references to reports to be submitted.

c. Personnel Movements—Troops.

- (1) *Military authority index numbers (MAIN).* Purposes, composition, methods, and procedures for assignment and use; marking on and eradicating from trains.
- (2) *Halts.* Types; policies, procedures, and responsibilities for establishment and conduct.
- (3) *Travel warrants.* Types, forms, authority, and responsibilities for issue, distribution, and usage.
- (4) *Troop-train commanders.* Appointment, responsibilities, and functions; relationship with transportation personnel; instructions to be furnished.
- (5) *Rations and water.* Responsibilities and procedures for securing, furnishing en route, and disposition at destination.
- (6) *Discipline of troops.* Responsibilities and command policies, police of rail equipment, sanitation.
- (7) *Diversions.* Authority for ordering, responsibilities and procedures for effecting, reference to reporting.
- (8) *Records and reports.* Responsibilities and methods for the maintenance of specific records and appropriate references to reports to be submitted.

4.8 Outline of Standing Operating Procedure for Transportation Railway Service

a. General. Policies and procedures for—

- (1) Integration of rail transportation in the theater transportation net.
- (2) Operational control.
- (3) Coordination with adjacent commands for use of rail capacity and support of operating units.
- (4) Coordination of the theater rail plan for selection, rehabilitation, and operation of rail lines in support of theater strategic plans.

b. Mission. Rail net and facilities operated; terminals, installations, and commands supported.

c. Organization. Operating units available, location, and operating limits.

d. Functions. Responsibilities for operation and maintenance of military railways, equipment, and freight, passenger, and special trains.

e. Planning.

- (1) Long-range planning responsibility and procedures; selection of rail primary and alternate routes; determination of line capacity, troop equipment, and supply requirements; rehabilitation and project requirements; communications and security requirements; demolition plans.
- (2) Current operational plans; current rail line capacity and requirements; phases of operation; selection and rehabilitation of new or additional railheads, yards, and installation facilities.

f. Operations. Procedures for dissemination and implementation of movement programs; coordination with transportation movements officer; priorities for and utilization of rail equipment; responsibilities for preparation and compilation of operational and situation reports; procedures for ordering and documentation of cars; responsibilities for scheduling special trains; construction and use of rail car spanners, responsibility and methods of loading, blocking, bracing, and inspecting loaded cars.

g. Maintenance. Responsibility, procedures, inspections, reports, and standards for maintenance of military and utility railway facilities and equipment, including organizational, field, and depot maintenance.

h. Supply. Responsibility and procedures for requisitioning, stocking, distributing, maintaining levels of, disposing of excess, and accounting for railway operating and maintenance supplies; requirements and priorities for major items, including locomotives and rolling stock.

i. Intelligence and Reconnaissance. Responsi-

bility and procedures for collecting, processing, disseminating, and using intelligence.

j. Security. Procedures, responsibility, coordination, and requirements for security of supplies en route by rail and security of trains and rail line-of-communication facilities; defense and demolition plans.

k. Records and Reports. Responsibility and procedures for reports: railway operation, situation, personnel status, equipment maintenance and inspection, equipment status, and project.

l. Training. Responsibility for conducting unit and technical training.

4.9 Maximum Bulk Loading of Typical U.S. Freight Cars

The rated weight capacity of a car does not mean that the car can carry the rated tonnage of all items. For many types of cargo, the cubic capacity of the car is reached ahead of the rated capacity. When this occurs, the tonnage that the car can carry represents its actual capacity.

a. High Density Items. Freight cars loaded with high density items can nearly always be loaded to their rated capacity. Examples of high density items are ammunition, barbed wire, cement, flour, gravel, corrugated iron, rails, rifles in chests, sand, stone, sugar, telephone wire, and engineer tools.

b. Lighter Bulk Items. Some items for which the cubic capacity of the car is reached at the time of or before the rated tonnage has been loaded are listed below.

Rated	Car capacity in short tons		
	30	40	50
Actual, by items:			
Blankets, baled	27	32	40
Bread	19	24	30
Canned goods in boxes	30	36	45
Clothing, baled	27	32	40
Hay, baled	15	20	25

4.11 Railway Gages (in Inches) by Area

Gages	23 3/8	24	29 1/2	30	35	36	37	37 3/8	37 1/2	39 3/8	40	41 1/4	41 1/2	41 3/8	42	56 1/2	56 3/8	57 1/2	60	63	66
<i>a. Africa.</i>																					
Algeria										x				x		x		x			
Cameroun															x						
Central African Republic															x						
Chad									x						x						

Car capacity in short tons

Meat	15	24	35
Motor vehicle parts	24	28	40
Oats	18	24	30
Sandbags	21	24	30
Tentage	15	20	30
Ties, railroad	19	26	32

4.10 Clearances—General

Overhead clearances and platform heights are measured from top of rail; side clearances from centerline of track. Clearances below those specified are dangerous, and protection must be provided by appropriate warning signs or devices. For example, telltales must be used for overhead clearances ranging between 18 to 22 feet. Unless local condition require greater clearances, the standard minimum clearances are as follows:

	Meters	Feet and inches
<i>a. Overhead.</i>		
Wires:		
High voltage	8.53	28'0"
Other	8.23	27'0"
Structures	6.71	22'0"
<i>b. Side.</i>		
Buildings	2.59	8'6"
Canopies:		
Up to 15' 6"	2.59	8'6"
Higher than 15' 6"	1.68	5'6"
Platforms:		
3' 9"	1.88	6'2"
4'	1.52	5'0"
Refrigerator platforms:		
3' 2"	1.88	6'2"
4' 7"	2.59	8'6"
<i>c. Enginehouse Entrance.</i>		
Overhead	5.18	17'0"
Side	1.98	6'6"

d. Bridge and Tunnel. Standard single-track bridge and tunnel clearances are shown in figure 4.2.

Gages	23½	24	29½	30	35	36	37	37½	37½	39½	40	41¼	41½	41½	42	56½	56½	57½	60	63	66
Congo, Republic of (Brazzaville)		x								x					x						
Congo, Republic of (Leopoldville)		x								x					x						
Dahomey															x						
Egypt			x	x						x						x					
Eritrea							x														
Ethiopia										x											
Gabon										x					x						
Ghana															x						
Guinea				x																	
Ivory Coast				x											x						
Kenya										x											
Liberia				x																	
Libya							x		x												
Malagasy										x											
Mali																x					
Mauritania										x						x					
Morocco																x					
Niger									x							x					
Nigeria				x											x						
Nyasaland															x						
Portuguese East Africa (Mozambique)				x											x						
Portuguese West Africa (Angola)		x								x					x						
Republic of South Africa		x													x						
Reunion										x											
Rhodesia															x						
Senegal																x					
Sierra Leone				x																	
Somalia										x											

Gages	23%	24	29 1/2	30	35	36	37	37 1/2	37 1/4	39 1/2	40	41 1/4	41 1/2	41 1/4	42	56 1/2	56 1/4	57 1/2	60	63	66
Sudan															x						
Swaziland															x						
Tanganyika										x											
Togo															x						
Tunesia										x						x					
Uganda										x											
Upper Volta															x	x					
<i>b. Asia.</i>																					
Afganistan										x						x			x		
Borneo										x											
Burma										x											
Cambodia										x											
Ceylon																					x
China																x					
Formosa		x		x									x								
India		x		x						x											x
Indonesia				x											x	x					
Iran																x			x		
Iraq										x						x					
Israel																x					
Japan															x	x					
Jordan												x									
Korea				x												x					
Laos										x											
Lebanon												x				x					
Malaya										x											
Nepal										x											x
Pakistan										x	x										x
Saudi Arabia												x				x					
Syria												x				x					
Thailand										x											

Gages	23½	24	29½	30	35	36	37	37½	37¾	39½	40	41¼	41½	41¾	42	56½	56¾	57½	60	63	66
Tibet										x											
Turkey			x							x			x			x			x		
USSR										x									x		
Vietnam										x											
<i>c. Europe.</i>																					
Albania										x						x					
Austria										x						x					
Belgium										x						x					
Bulgaria	x			x												x					
Czechoslovakia																x					
Denmark																x					
Estonia																			x		
Finland																			x		
France										x						x					
Germany				x						x						x					
Greece										x						x					
Hungary																x					
Ireland																				x	
Italy								x								x	x				
Latvia	x		x													x			x		
Lithuania	x		x													x			x		
Luxembourg										x						x					
Netherlands																x					
Norway															x	x					
Poland			x													x			x		
Portugal										x											x
Rumania						x										x					
Spain						x				x											x
Sweden					x										x	x					
Switzerland										x						x					
Turkey																x					

Gages	23%	24	29 1/2	30	35	36	37	37 1/2	37 1/4	39 1/2	40	41 1/4	41 1/2	41 1/4	42	56 1/2	56 1/2	57 1/2	60	63	66
USSR										x									x		
United Kingdom																x				x	
Yugoslavia				x						x						x					
<i>d. Central America and West Indies.</i>																					
Costa Rica															x						
Cuba																x					
Dominican Republic				x							x										
El Salvador						x															
Guatemala						x															
Haiti				x							x										
Honduras						x									x						
Jamaica																x					
Nicaragua															x						
Panama						x													x		
Puerto Rico										x											
Trinidad																x					
<i>e. North America.</i>																					
Canada						x										x					
Newfound- land															x						
Mexico						x										x					
United States (CONUS)																x					
Alaska						x										x					
Hawaii (see Pacific Ocean)																					
<i>f. South America.</i>																					
Argentina			x							x						x					x
Bolivia										x											
Brazil		x		x						x										x	
British Guiana																x					

Gages	23 3/8	24	29 1/2	30	35	36	37	37 3/8	37 1/2	39 1/8	40	41 1/4	41 1/2	41 5/8	42	56 1/2	56 3/8	57 1/8	60	63	66
Chile		x		x						x					x	x					x
Colombia						x				x											
Dutch Guiana										x											
Ecuador				x											x						
Paraguay																x					
Peru						x				x						x					
Uruguay																x					
Venezuela		x		x		x				x					x	x					
<i>g. Pacific Ocean.</i>																					
Australia				x											x	x				x	
Hawaii						x										x					
New Caledonia										x											
New Zealand															x						
Philippines															x						
Tasmania															x						

4.12 Clearances and Gages

The sample clearance diagrams shown in figures 4.3 and 4.4 refer to the distance that equipment or cargo may project to the side at various heights above track level. They are composites incorporating the smallest dimensions of all similar dimensions of the countries having the gages shown (par. 4.11); therefore, all the limiting clearances shown in the composites will not exist simultaneously on any particular rail line. A clearance diagram for the rail line(s) over which operations are to be conducted must be obtained or made. Horizontal distances shown in the diagrams should not be confused with the track gage. The composite clearances in figure 4.3 show minimum clearances for the standard-gage (56 1/2 inch), and for the broad-gage track indicated. Figure 4.4 shows clearances for three sizes of narrow-gage track. Examples of the use of the diagrams are given below.

a. In figure 4.3, a vertical clearance of 3 feet 8 inches can be depended upon for a width clearance which is at least 9 feet 8 inches. In the same figure, a vertical clearance of 9 3/4 inches can be

depended upon if the width clearance is not less than 8 feet 1 1/2 inches.

b. In figure 4.4, a vertical clearance between 13 3/4 inches and 3 feet 4 inches can be depended upon when the width clearance is not less than 8 feet.

4.13 Bridge Capacity

a. *Cooper's E Rating.* This figure indicates, in thousands of pounds, the weight a bridge can support for each driving axle of a locomotive. For example, the following method is used to determine the rating a bridge must have if it is to be crossed safely by a 2-8-0 locomotive weighing 140,000 pounds on drivers:

A 2-8-0 locomotive has four driving axles.

140,000 (weight of locomotive) divided by 4 (number of driving axles) equals 35,000 pounds (weight per driving axle).

Therefore, any bridge which has a rating of E-35 or above can be crossed safely by this locomotive.

b. *Steel I-Beam Bridge* (fig. 4.5). The table below refers to bridges already constructed with two, four, six or more steel stringers or girders of

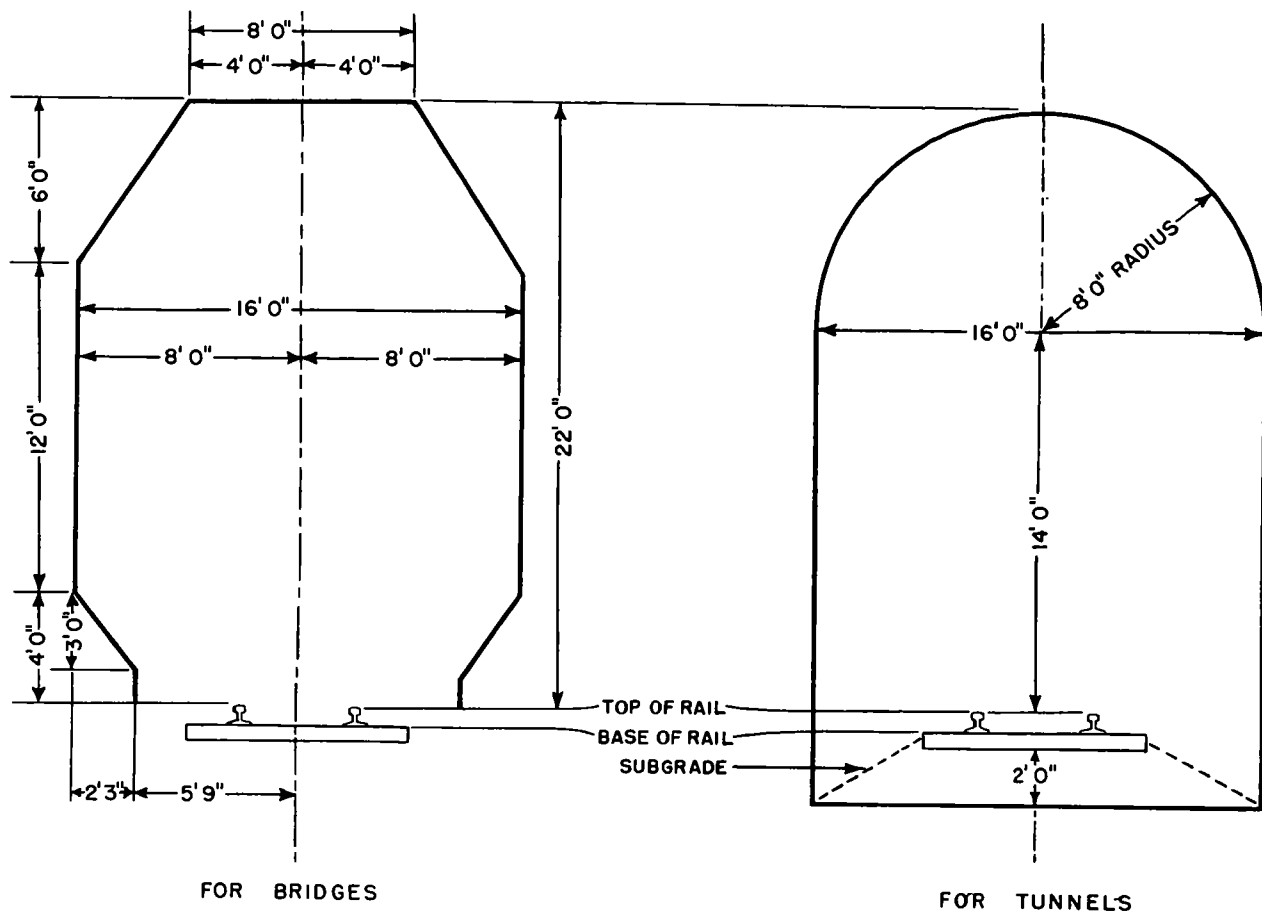


Figure 4.2. Standard single-track bridge and tunnel clearances.

equal dimensions. To estimate the capacity of a railway bridge with this type construction, the width and thickness of the lower flange of one stringer are measured at the center of the span length; the depth and length of the stringer are also measured. Using the table below, the steel

stringer that is nearest to these dimensions is selected, and the corresponding E-rating of the bridge is read. The rating is reduced according to the age and condition of the bridge. The quantity of reduction must be determined by qualified personnel, normally from the Corps of Engineers.

[illegible]

c. *Wooden Bridge* (fig. 4.6). For a bridge with wooden stringers, the width of each stringer is measured under one track at the center of the length span and added to obtain total stringer width. In figure 4.6 the total stringer width is $3 \times W$. The depth and length of one stringer are also measured. The following table is used with the same procedures as the table in *b* above.

Stringer dimensions (inches)		Span length (feet)							
Width	Depth	10	12	14	16	18	20	22	
18	12	E-16	E-12						
18	14	E-22	E-18	E-10					
18	16	E-28	E-20	E-15	E-10				
18	18	E-38	E-26	E-18	E-14	E-12			
20	12	E-18	E-12						
20	14	E-25	E-17	E-12					
20	16	E-33	E-23	E-16	E-12	E-10			
20	18	E-43	E-29	E-21	E-16	E-13	E-10		
24	12	E-22	E-15	E-11					
24	14	E-30	E-21	E-14	E-11				
24	16	E-40	E-28	E-20	E-15	E-12			
24	18	E-52	E-36	E-25	E-19	E-15	E-12	E-10	
36	12	E-34	E-23	E-17	E-12	E-10			
36	14	E-47	E-32	E-23	E-17	E-14	E-11		
36	16	E-62	E-43	E-30	E-23	E-19	E-15		
36	18	E-78	E-53	E-39	E-30	E-24	E-20	E-16	
40	12	E-38	E-26	E-19	E-14	E-11			
40	14	E-52	E-36	E-26	E-20	E-16	E-12		
40	16	E-69	E-47	E-35	E-26	E-21	E-17		
40	18	E-87	E-60	E-44	E-34	E-27	E-22	E-18	
48	12	E-46	E-31	E-23	E-17	E-13			
48	14	E-63	E-43	E-31	E-24	E-19	E-15		
48	16	E-83	E-57	E-41	E-32	E-26	E-21		
48	18	E-105	E-73	E-53	E-41	E-33	E-27	E-22	
54	12	E-52	E-35	E-27	E-19	E-15			
54	14	E-72	E-49	E-35	E-22	E-18			
54	16	E-94	E-65	E-46	E-36	E-29	E-24		
54	18	E-119	E-82	E-60	E-46	E-38	E-30	E-25	
60	12	E-58	E-40	E-30	E-22	E-17			
60	14	E-79	E-55	E-39	E-30	E-35	E-20		
60	16	E-104	E-72	E-52	E-40	E-33	E-27		
60	18	E-132	E-92	E-67	E-52	E-42	E-34	E-28	

4.14 Loading Open-Top Cars

Military equipment loaded on U.S. Army cars traveling over the lines of common carriers and on cars belonging to common carriers within the continental United States must meet the loading standards of the individual railroad and those of the AAR (Association of American Railroads). Cars loaded on foreign lines should meet the blocking and lashing standards of the area involved. The standards for and methods of blocking, nailing, and bracing for some typical military

loadings are given in this paragraph. Association of American Railroads (AAR) regulations dated 1 February 1960 and revised in January 1962, *Rules Governing the Loading of Department of Defense Material on Open-Top Cars*, should be followed. The following examples apply only to the loading of flatcars and composite gondolas with wooden floors with the equipment listed in *a* through *d* below and illustrated in figures 4.7 through 4.10. The letters in the item column refer to the letters shown in the illustrations. In all examples, brake wheels have the clearances shown in figure 4.11. The various wooden blocks, cut to specific patterns and numbered, are illustrated in figure 4.12.

a. Six-Wheel Truck (fig. 4.7).¹

Item	No. of pieces	Description
A		Brake-wheel clearance (fig. 4.11).
B	8	Blocks, pattern 16 (1, fig. 4.12). Locate 45° portion of block against front and rear of front wheels, in front of outside intermediate wheels, and in back of outside rear wheels. Secure heel of block to floor with three 40-penny nails and toenail that portion under tire to floor with two 40-penny nails before items D and E are applied. Substitute, if desired, at each location, blocks, pattern 17 (2, fig. 4.12), or blocks, pattern 18 (3, fig. 4.12).
C	8	2 by 4 by 12 inches. Locate against block pattern 18 (3, fig. 4.12) lengthwise of car, and secure to floor with four 30-penny nails. Not required when blocks, patterns 16 (1, fig. 4.12) and 17 (2, fig. 4.12), are used.
D	1 each outside wheel.	Suitable material, such as waterproof paper, burlap, etc. Locate bottom portion under items E, top portion to extend 2 inches above items E.
E	6	Each consisting of 2 pieces of wood 2 by 4 by 36 inches. Secure lower piece to floor with four 30-penny nails and top piece to one below in like manner.
F	2 each axle.	At each location use four strands of No. 8 gage, black annealed wire. Pass over axle, springs,

b. Landing Vehicle, Wheeled, 2½-ton, 6 × 6 (fig. 4.8).¹

Item	No. of pieces	Description
A		Brake-wheel clearance (fig. 4.11).
B	8	Blocks, pattern 24 (5, fig. 4.12). Locate in front and rear of front wheels, in front of intermediate wheels, and back of rear wheels, and secure to floor with five 30-penny nails in each.
C	8	2 by 4 by 20 inches. Secure upper end to item B and lower end to floor with two 30-penny nails at each location.
D	8	2 by 4 by 12 inches. Locate against bottom of item C and secure each to floor with three 30-penny nails.
E	6	Suitable material, such as waterproof paper, burlap, etc. Locate bottom portion under items F, top portion to extend 2 inches above items F.
F	6	Each consisting of 2 pieces of 2 by 4 by 36 inches. Secure lower piece to floor with four 30-penny nails and top piece to one below in like manner.
G	2 each axle.	1-inch, No. 14 Birmingham wire gage, hot-rolled steel, with anchor plates, pattern 19 (4, fig. 4.12). Locate over axle, springs, or spring shackles, and secure each plate to floor with eight 20-penny, cement-coated nails. Substitute, if desired, at each location, four strands of No. 8 gage black annealed wire. Pass around item H and twist taut after item H has been nailed in place.
H	1 each item G.	2 by 4 by 18 inches. Secure to floor, lengthwise of car, with four 30-penny nails. Not required when steel straps are used, pattern 19 (4, fig. 4.12).
J	2	1-inch, No. 14 Birmingham wire gage, hot-rolled steel, with anchor plates, pattern 19 (4, fig. 4.12). Pass through towing clevises and secure each plate to floor with eight 20-penny cement-coated nails. Substitute,

See notes at end of *d* below.

Item	No. of pieces	Description
		if desired, at each location, four strands of No. 8 gage black annealed wire. Pass through towing clevises, underneath, and around item K, and twist taut after item K has been nailed in place. Not required when steel straps are used, pattern 19 (4, fig. 4.12).
K	1 each item J.	2 by 4 by 18 inches. Secure to floor, lengthwise of car, with four 30-penny nails. Not required when steel straps are used, pattern 19 (4, fig. 4.12).
L	1	Four strands of No. 8 gage, black annealed wire. Loop around towing hook and through opposite stake pockets. Not required for units loaded in gondola cars.

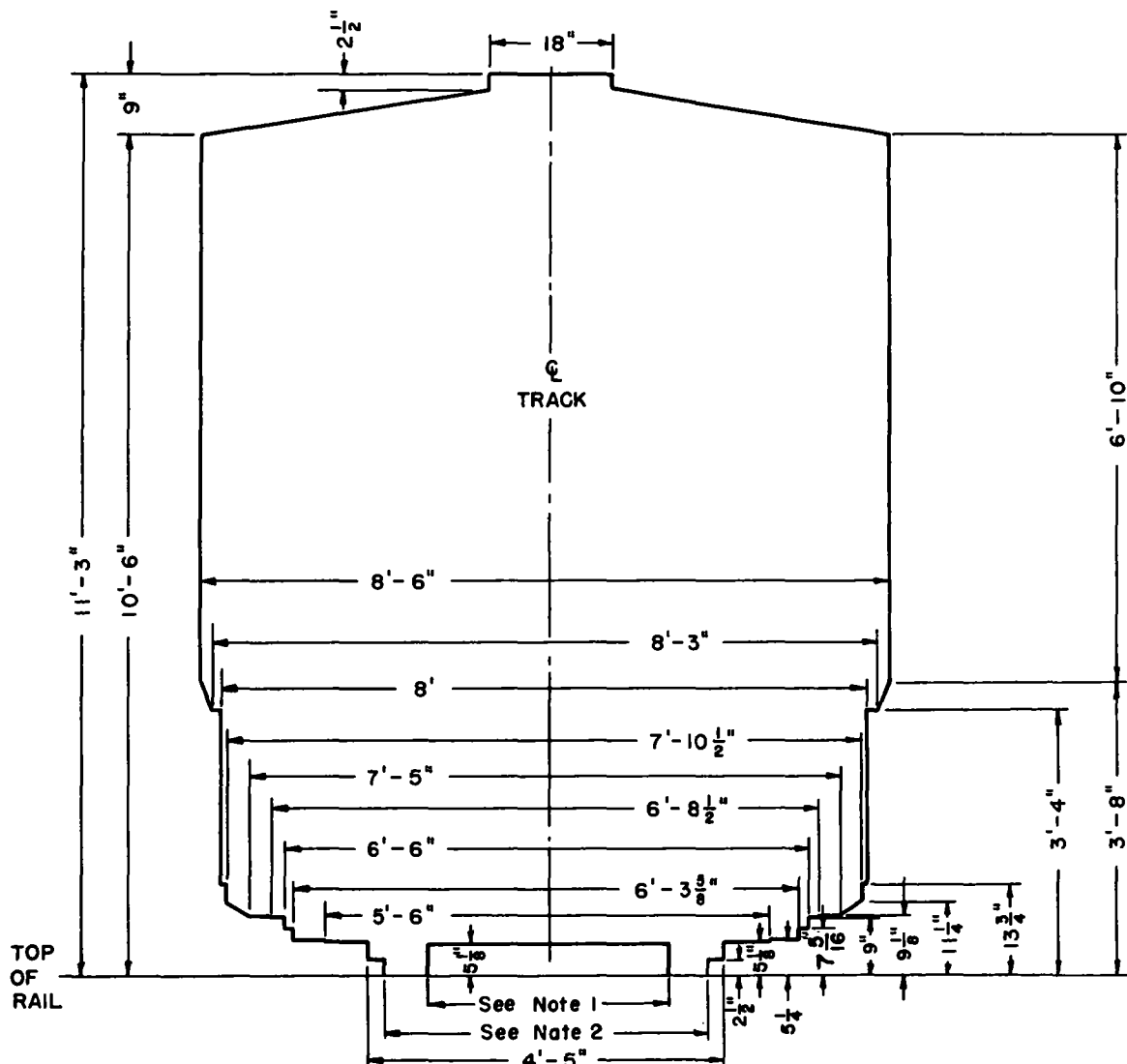
c. Mounted Gun or Howitzer (fig. 4.9).^{1 2}

Item	No. of pieces	Description
A		Brake-wheel clearance (fig. 4.11).
B	4	Blocks, pattern 16 (1, fig. 4.12). Locate 45° portion of block at front and rear wheels. Secure heel of block to floor with three 40-penny nails and toenail that portion under tire to floor with two 40-penny nails before items C are applied.
C	2	Each consisting of 2 pieces of 2 by 4 by 36 inches. Secure lower piece to floor with three 40-penny nails and top piece to one below in like manner.
D	2	Support, pattern 62 (8, fig. 4.12), length ¼ inch longer than the distance between point of support on gun carriage and floor. Place between floor and gun carriage to partially relieve weight on tires. Secure each to floor with six 40-penny nails.
E	2	Four strands of No. 8 gage, black annealed wire. Pass through holes in wheels and secure to stake pockets.
F	2 for single spade, 4 for	6 by 8 by 24 inches, cut to fit contour of spade. Locate in front

Item	No. of pieces	Description
	double spade.	and rear of spade. Toenail to floor with five 40-penny nails.
G	2 each item F.	Each consisting of 2 pieces of 2 by 4 by 12 inches. Secure lower piece to floor, against item F, with three 40-penny nails and top piece to one below in like manner.
H	2	2 by 4 by 12 inches. Locate against each side of spade and secure to floor with three 40-penny nails.

Item	No. of pieces	Description
J	1 pair.	Stakes or green saplings. Locate $\frac{1}{3}$ distance from end of gun trail to center of wheels.
K	1	Six strands, No. 8 gage, black annealed wire. Loop around and over top of rear end of gun trail and secure to opposite stake pockets. Substitute, if desired, 2-inch by .05-inch high-tension bands or $\frac{1}{2}$ -inch steel cables.

See notes at end of *d* below.



Note 1: 2'-8 $\frac{3}{4}$ " for 36-inch track gage
3' for 39 $\frac{3}{8}$ " - and 42-inch track gage

Note 2: 4' for 36- and 39 $\frac{3}{8}$ "-inch track gage
4'-5" for 42-inch track gage

Figure 4.4. A composite clearance diagram: 36-, 39 $\frac{3}{8}$ -, and 42-inch gages.

d. Tanks and Similar Units, From 60,000 to 100,000 Pounds (fig. 4.10).^{1 2}

Item	No. of pieces	Description
A		Brake-wheel clearance (fig. 4.11).
B	2	Blocks, pattern 31 (7, fig. 4.12). Locate one against each rear crawler tread.
C	2	Blocks, pattern 30 (6, fig. 4.12). Locate one against each front crawler tread.
D	1 each items B and C.	2 by 4 by 20 inches. Locate one on inside of items B and C and secure to floor with six 20-penny nails.
E	2 each items B and C.	Each consisting of 2 pieces of 2 by 4 by 12 inches. Locate against ends of items B and C. Secure lower piece to floor with four 20-penny nails and top piece to one below in like manner.
F	2 each unit.	Each consisting of 2 pieces of 2 by 4 by 14 inches. Locate on floor against inside of each crawler tread, and secure lower piece to floor with twelve 30-penny nails and top piece to one below in like manner.
G	3 each unit.	Each consisting of 2 pieces of 2 by 4 inches long enough to fill space between items F. Locate one near center and one near each end of items F. Secure lower piece to floor with four 30-penny nails and top piece to one below in like manner.
H	6	Each consisting of 2 pieces of 6 by 6 inches, length to suit, cut to fit contour of bogie wheels. Locate one piece between inside and outside wheels of each bogie assembly.
J	6	Each consisting of 2 pieces of 4 by 4 inches, length to suit. Locate against bogie wheels on top of item H.
K	6	Each consisting of 2 pieces of 4 by 4 inches, long enough to fill space between items H. Toenail each to items H with two 20-penny nails.
L	12	Each consisting of two strands No.

Item	No. of pieces	Description
		8 gage, black annealed wire. Pass under crawler tread and around items H and J. Substitute, if desired, at each location, one $\frac{3}{4}$ - by .035-inch high-tension band. Use staples or nails bent over to retain bands or wires in position.
M	4	1 $\frac{1}{4}$ -inch diameter rods. Attach to lifting lugs and pass through stake pockets and $\frac{1}{2}$ - by 4- by 10-inch plates underneath stake pockets on opposite sides of car. Substitute, if desired, $\frac{5}{8}$ -inch steel cable, doubled.

¹ Set handbrake and wire, or block, lever. When tiedown rods are found slightly loose in transit, they need not be tightened.

² Place turret gun in straight forward position, and wire turret-lock hand-wheel and elevating-mechanism handwheel to prevent rotating. When unit is not equipped with built-in gun brace, apply two $\frac{1}{4}$ -inch high-tension bands, securing gun barrel to unit at each side. Rock a tracked vehicle forward and backward under its own power to take the slack out of the tracks and thus secure the vehicle to the blocks.

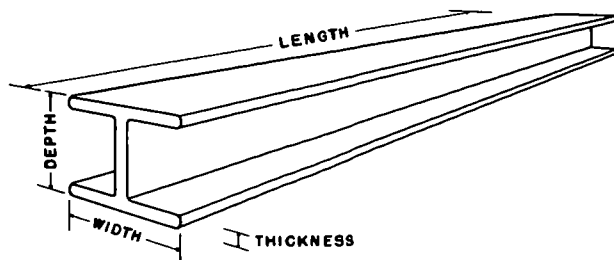


Figure 4.5. Measuring a steel stringer.

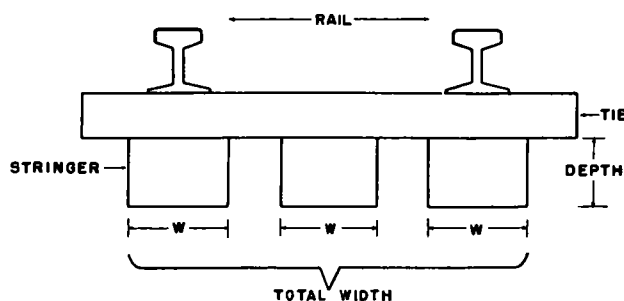


Figure 4.6. Measuring a wooden stringer.

4.15 High and or Wide Loads

a. Cars with high and/or wide loads create an operating hazard: both the cargo and the personnel working on the line are endangered. Every possible effort must be made to reduce such hazards.

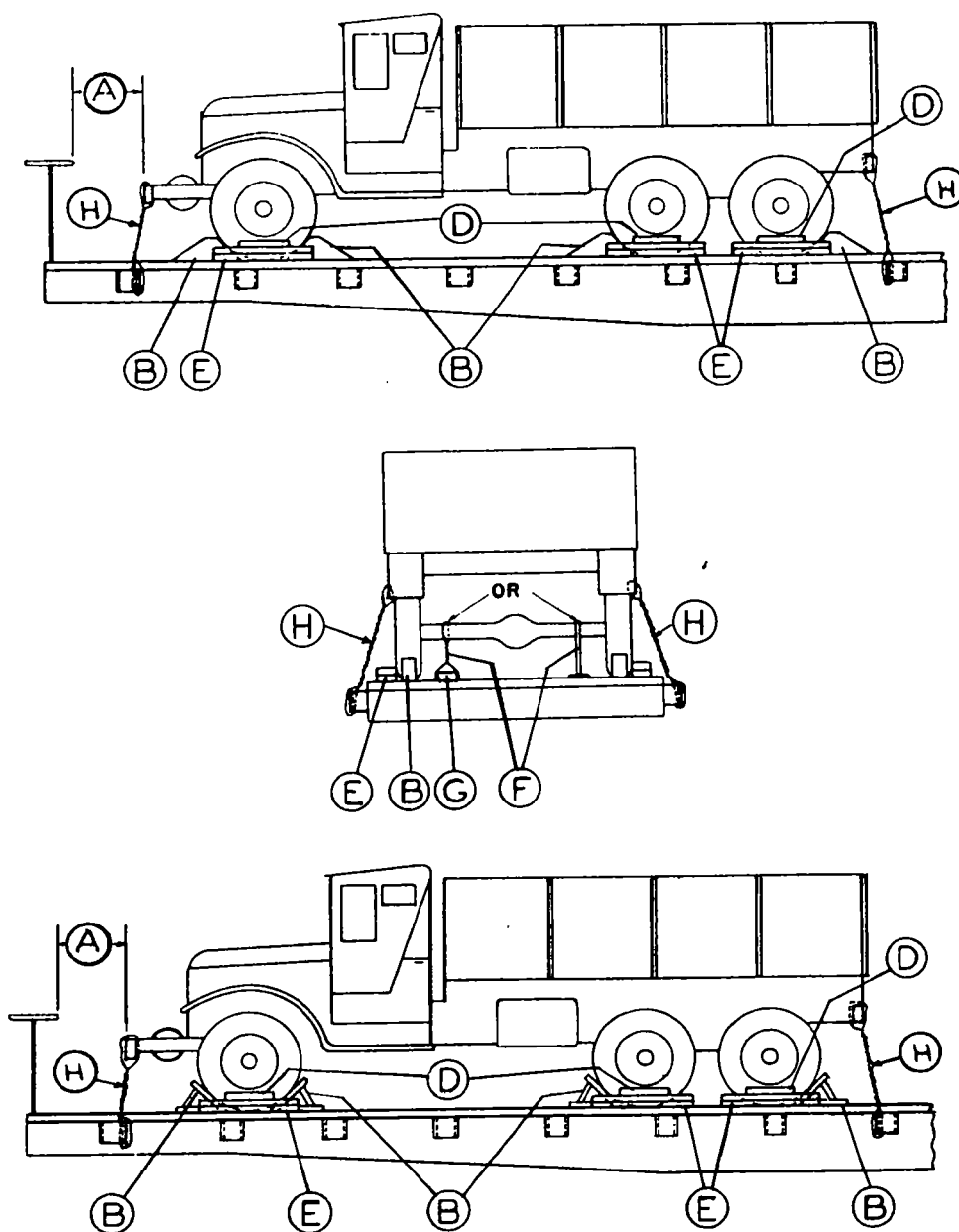


Figure 4.7. Loading a six-wheel truck on an open-top car.

b. The transportation officer initiating a high and/or wide load is responsible for coordinating the shipment with the shipping agency to effect the maximum reductions possible; for example, the removal of spotlights and tool kits, the lowering of booms, and the depressing of gun barrels.

c. When the movement of a high and/or wide load is unavoidable, a scale drawing should be given the serving carrier to determine rail transportability and, if transportable, to make necessary routing instructions.

d. It is essential that the dimensions provided the carrier be accurate and that they reflect the absolute minimum that can be achieved by the shipping agency. (The consignee's ability to reassemble dismantled equipment must be considered.)

e. Whenever possible, an item of equipment should actually be measured to determine its shipping cube. Dimensions from supply manuals, TM's, FM's, etc., should not be used without

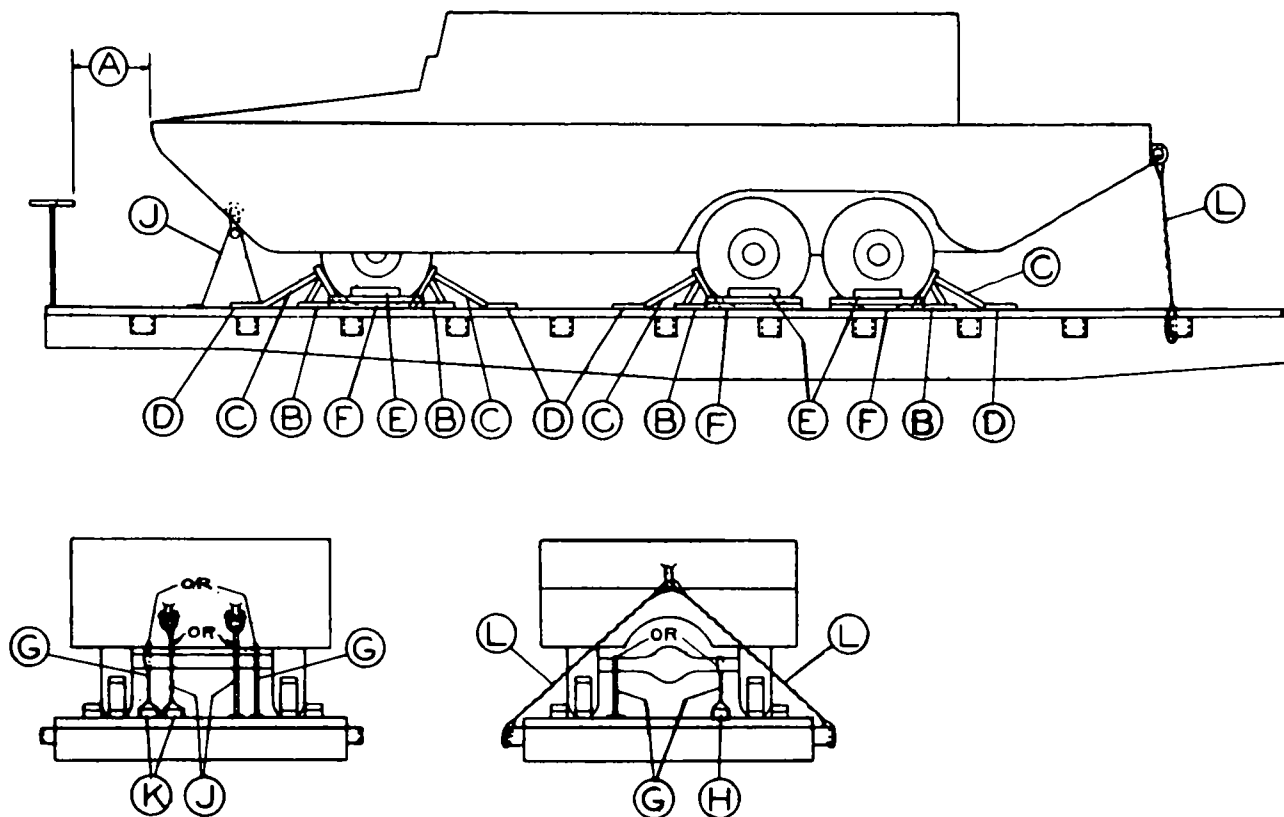


Figure 4.8. Loading a 2½-ton wheeled landing vehicle on an open-top car.

verification. Incorrect dimensions can be very dangerous and costly.

f. Trains containing high and/or wide loads must be operated at reduced speeds; everyone concerned must be informed of the situation.

4.16 Loading Explosives and Other Hazardous Cargo

For detailed information about handling explosives, see regulations of the Interstate Commerce Commission and pamphlets issued by the Bureau of Explosives, Association of American Railroads. Basic precautions are:

a. Lost space in loading packages in a car should be avoided by pressing each package firmly toward the end of the car as it is loaded.

b. High pressures on small areas must be avoided. The largest possible area of a package must be used to resist pressures. Bevel-edged boards must be nailed to the car floor to cover defects in the floor or projecting pieces of metal or nails. Cars with corrugated or pressed metal ends, not lined, and cars with bowed ends must be boarded up at the inside of the ends to the height of the load.

c. Placing a large shipment in one end of a car must be avoided. A shipment in excess of 12,000 pounds must not be loaded in one end of a car unless other freight is to be loaded in the other end to balance it. Failure to do this may cause the car to leave the track.

d. Bracing and blocking must be made with sound lumber, free from cross grain, knots, knot-holes, checks, or splits which impair the strength of the material or interfere with proper nailing.

e. Nails should be used plentifully and in the proper places.

- (1) Balanced nailing is important. All nails should be of such length as to have the necessary holding power and ample penetration into car walls, floors, or other bracing and blocking. To obtain the greatest holding power, nails must be long enough to nearly penetrate but not protrude through the timber holding the point of the nail. Nails must not be large enough to cause splitting; they should not be placed along one grain of the wood. Whenever possible, nails

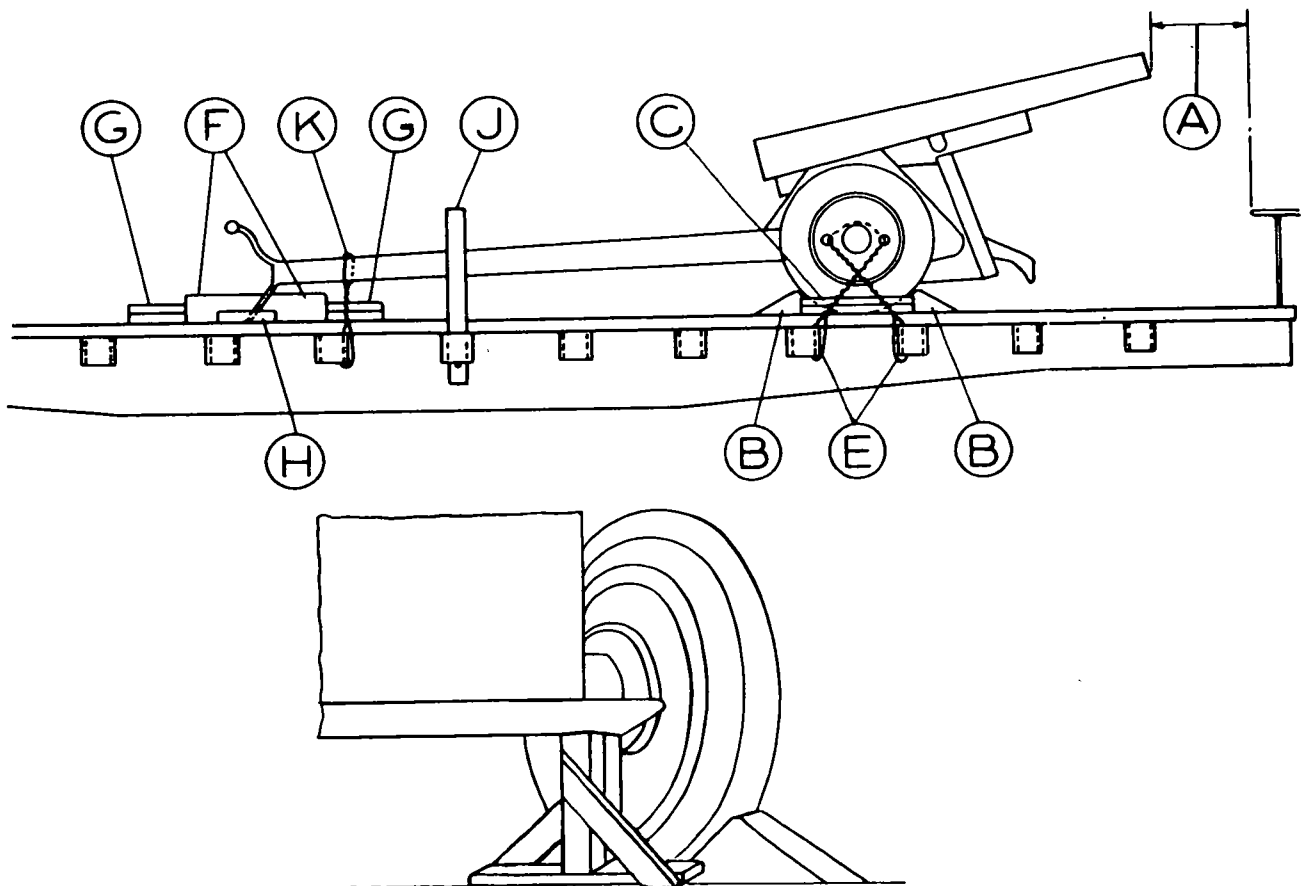


Figure 4.9. Loading a 37mm to 105mm mounted gun or howitzer on an open-top car.

should be driven straight—not toenailed. Brass or copper hammers should be used to nail braces around packages of explosives.

- (2) The lining of cars is only three-quarters or seven-eighths of an inch thick and has little holding power for large nails. Therefore, nails holding sidewall blocking should be driven into the heavy uprights supporting the lining.

f. The following must not be used:

- (1) Cars with end doors.
- (2) Cars with automobile loading devices unless the loading device is attached to the roof of the car so that it cannot fall.
- (3) Refrigerator cars except when—
 - (a) Authorized by the carrier or owner,
 - (b) Ice bunkers are protected by solid bracing, and
 - (c) Unfixed floor racks are removed.

g. When heavy loads are handled in and out of cars on lift trucks, a temporary steel plate or other

floor protection of suitable size must be used to prevent the truck from breaking through the floor.

h. When loading in closed cars, the following safety rules must be followed:

- (1) Lading must be so secured that it will not come in contact with side doors, or roll, or shift in transit.
- (2) Adequate stripping must be placed across each door opening to prevent lading from falling, rolling out of a doorway, or coming in contact with a door while in transit.
- (3) Load must be so placed in the car that there is not more weight on one side than on the other. One truck must not carry more than one-half the load limit stenciled on the car. Cars should be loaded as heavily as possible up to, but not exceeding, the load limit stenciled on the car. Loads should be placed in cars as shown in figure 4.13. The distances shown in the figure represent lengths of

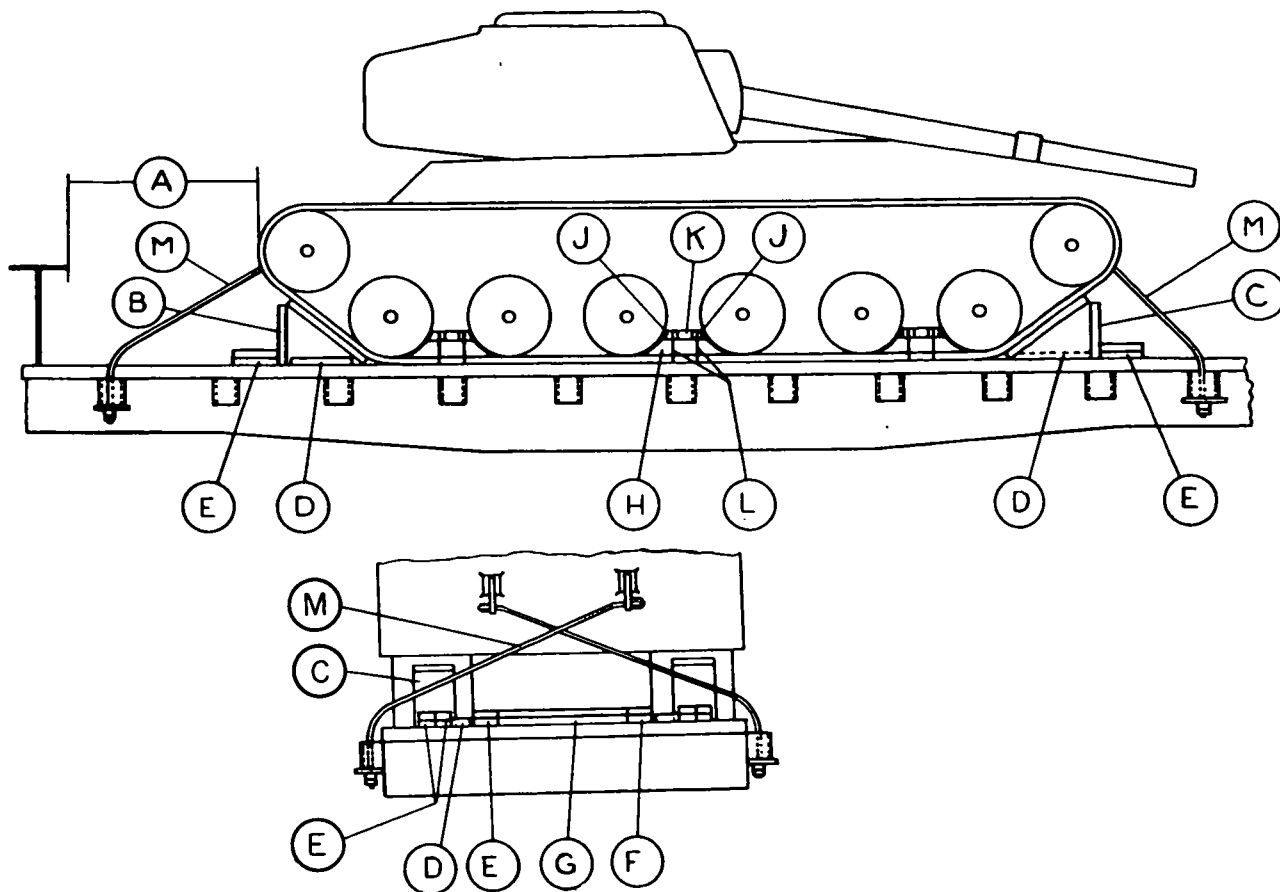


Figure 4.10 Loading a tank or similar unit, 60,000 to 100,000 pounds, on an open-top car.

different loads. Relative position on the car of each load is also shown.

- (4) Material loaded between truck centers and ends of car must not exceed 30 percent of the stenciled load limit (15 percent each end) when both ends are loaded and 10 percent when only one end is loaded. The percentage of stenciled load limits shown in figure 4.13 must not be exceeded for loads located between truck centers, measured lengthwise of car, except when car owner designates otherwise.

i. The following instructions apply in loading and blocking ammunition in clover-leaf packages. Less-than-carload shipments may be loaded and braced in the same manner as the partial shipment shown in figure 4.14. All space between sides of car and rows of bundles must be filled. All bundles must be tightly wedged in place at time of loading. Bulkhead braces for partial layers must be long enough to permit nailing to upright braces behind

car lining. Length will vary, depending on weight of lading supported. The filler strips nailed to the sides of the car must be extended across the doorway. No other doorway protection is required.

4.17 Marking Dangerous-Cargo Cars

a. *Loaded Cars.* Closed cars and tank cars containing dangerous ladings are marked with placards giving the contents. These cards, usually 10 to 14 inches square and printed with large red and black lettering, indicate the contents of the car and give special handling instructions. The placards are usually tacked to placard boards bolted to the outside of the car—one at each end and one on each door on each side of the car. Cars of all-steel construction often have a framed card pocket, one each in the four locations enumerated, into which the printed placards are slipped.

b. *Empty Cars.* Empty tank cars and boxcars are often placarded with notices that warn of lingering gases and fumes. These warning cards on cars stress that care must be used in switching the cars as well as in unloading their contents.

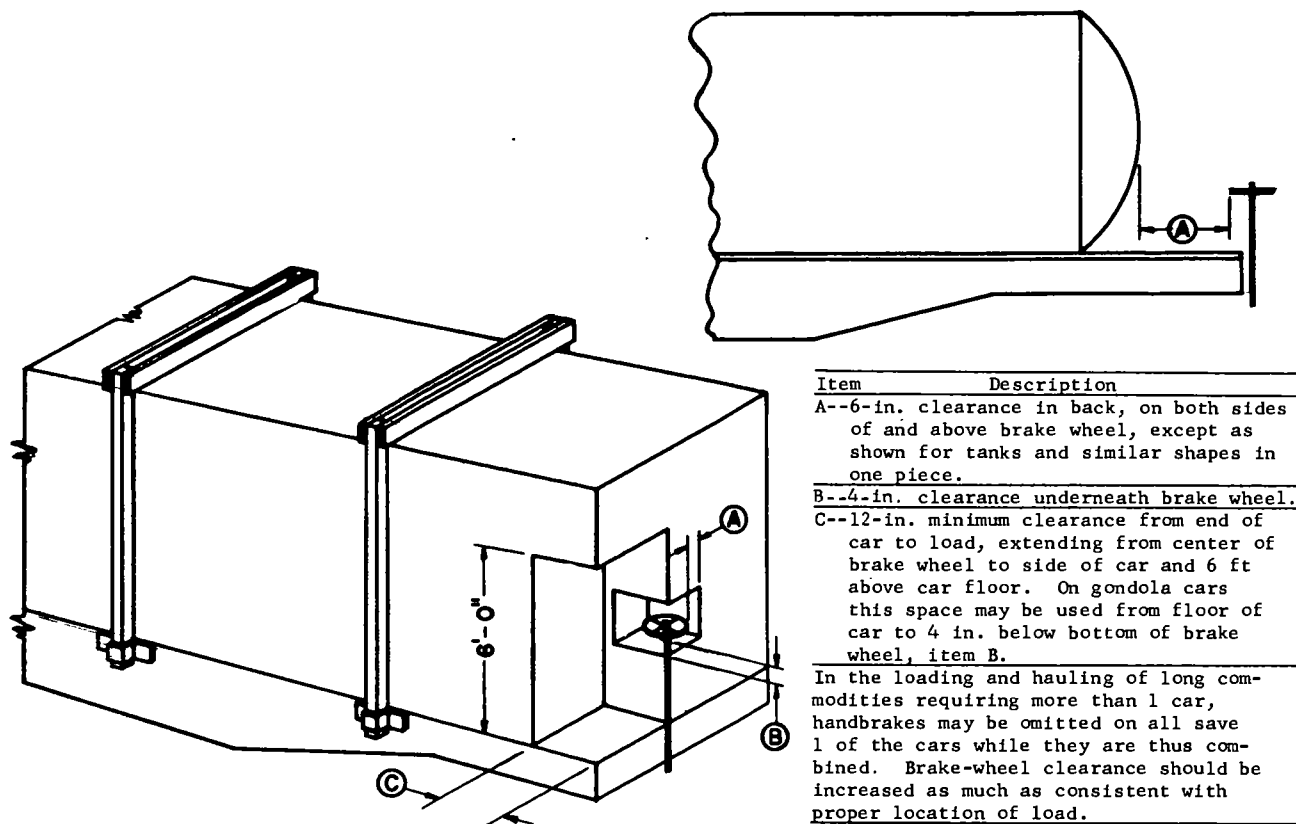


Figure 4.11. Brake-wheel clearance.

c. *Examples.* Typical car placards used on commercial and military railroads in the United States are shown in figure 4.15, and four-language placards for use by the Army in Europe are shown in figure 4.16.

4.18 Cargo Security

a. At Origin.

- (1) The shipper is responsible for the security of carload freight until the car is coupled to an engine or train for movement. *The shipper must be fully aware of this responsibility.*
- (2) Before loading, the shipper should inspect the car thoroughly to insure that it meets security requirements. Cars with holes or damaged places in floors, roofs, or sides or insure doors must be repaired before they are used.
- (3) The shipper is responsible for properly loading and bracing the load and for closing and sealing the car. Improperly stowed or braced loads may be damaged in movement and invite pilfering.

- (4) Loading should conform to the standards necessary for safe movement under existing operating conditions. In sealing closed cars, the best protection is provided by tightly twisting a 10-inch length of heavy-gage wire through the locking eyes and snubbing off the wire ends closely. Usually No. 8- or 10-gage wire is used. Zero-gage may be necessary when the pilferage or sabotage threat is acute. The door hasps of closed doors are always sealed with a thin, metallic seal on which a serial number is stamped. This seal is broken easily and provides little protection against pilferage. The absence or breakage of a seal indicates tampering. Shipments in open cars should be covered with securely fastened tarpaulins if required by nature of shipment. Small items shipped on flatcars should be fastened securely to the car floor.
- (5) The shipper prepares an accurate list of contents, prepares the waybills, and affixes

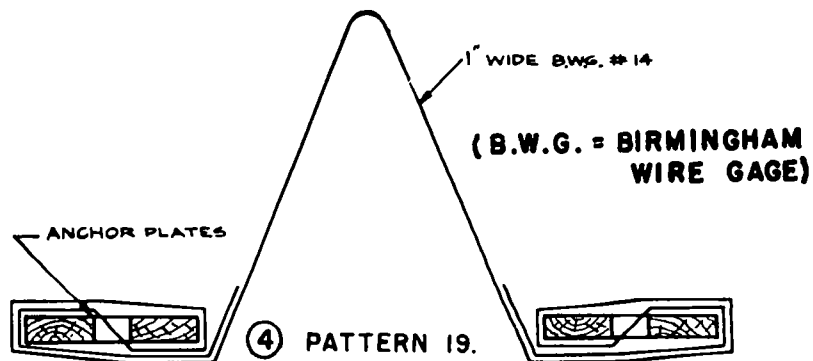
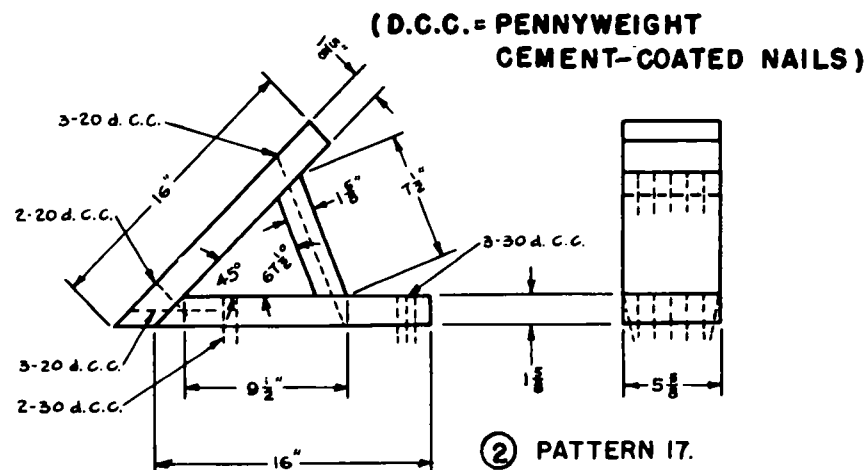
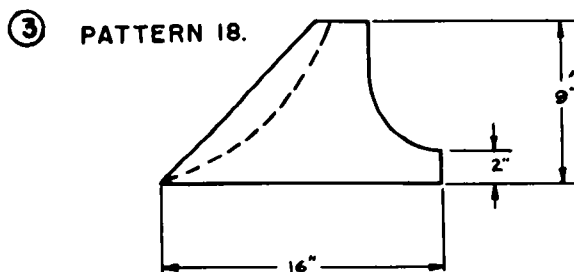
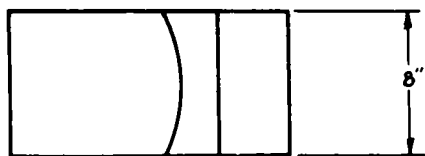
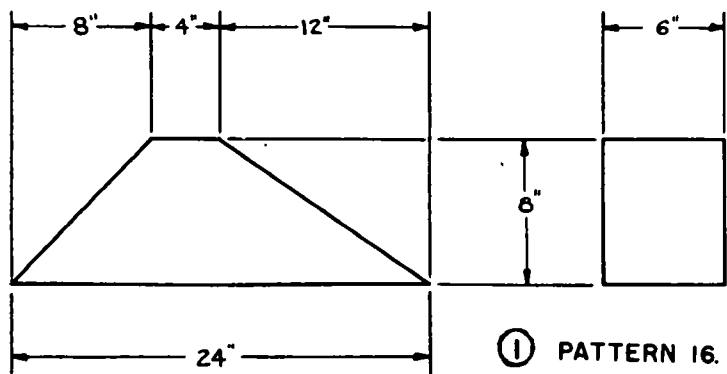


Figure 4.12. Chocks with dimensions and pattern numbers of the Association of American Railroads.

(D.C.C. & PENNYWEIGHT
CEMENT-COATED NAILS)

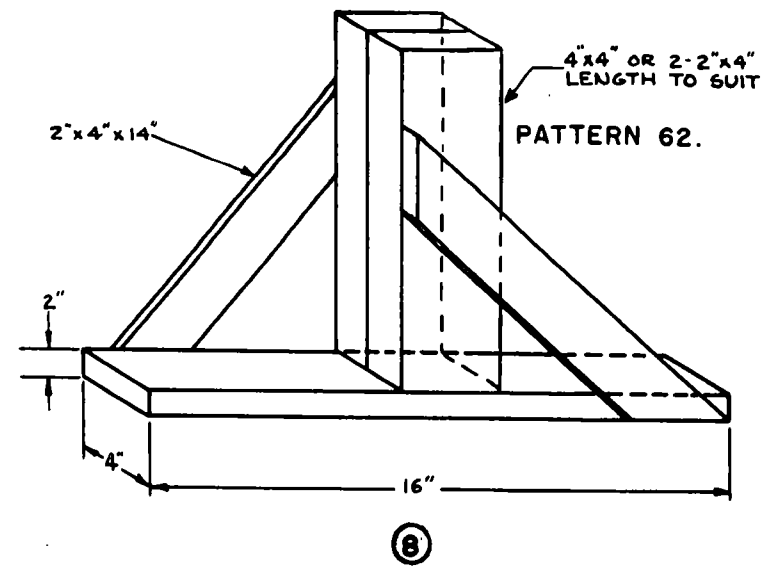
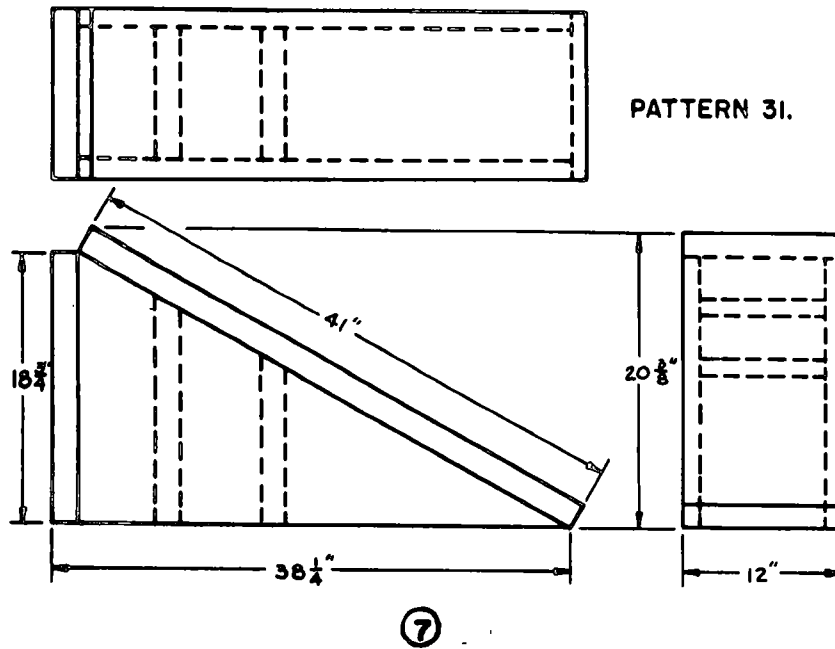
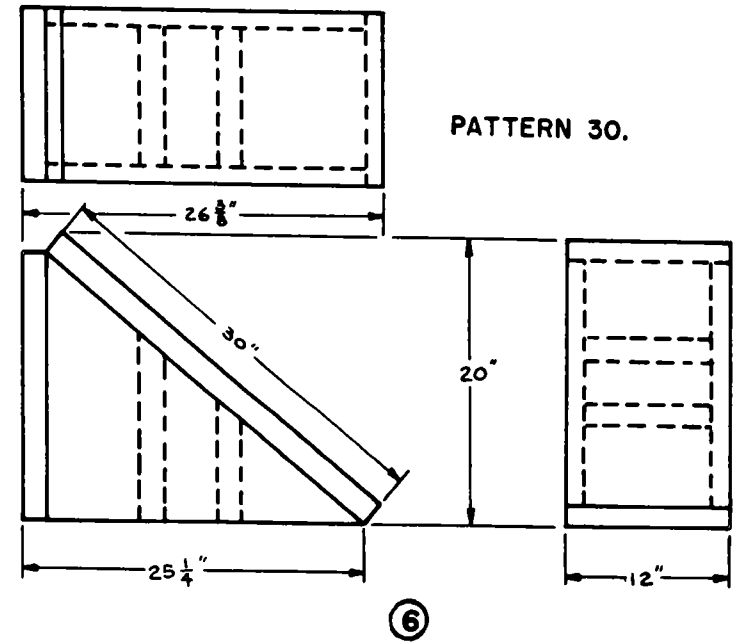
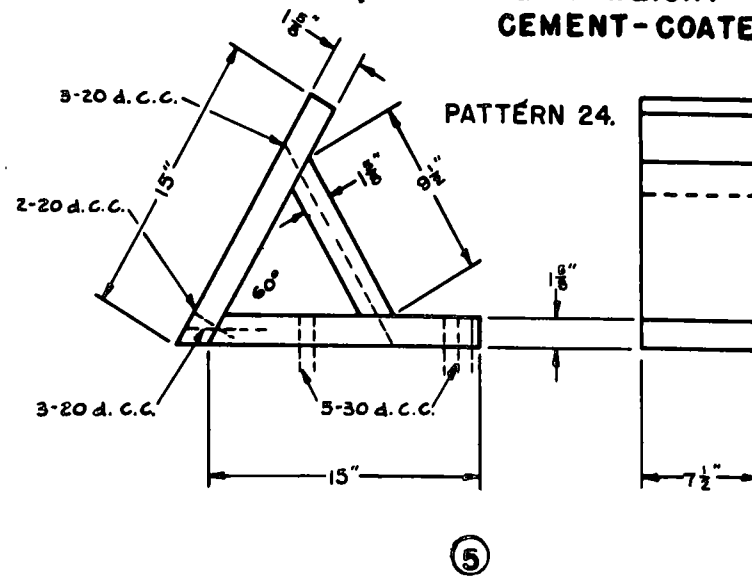
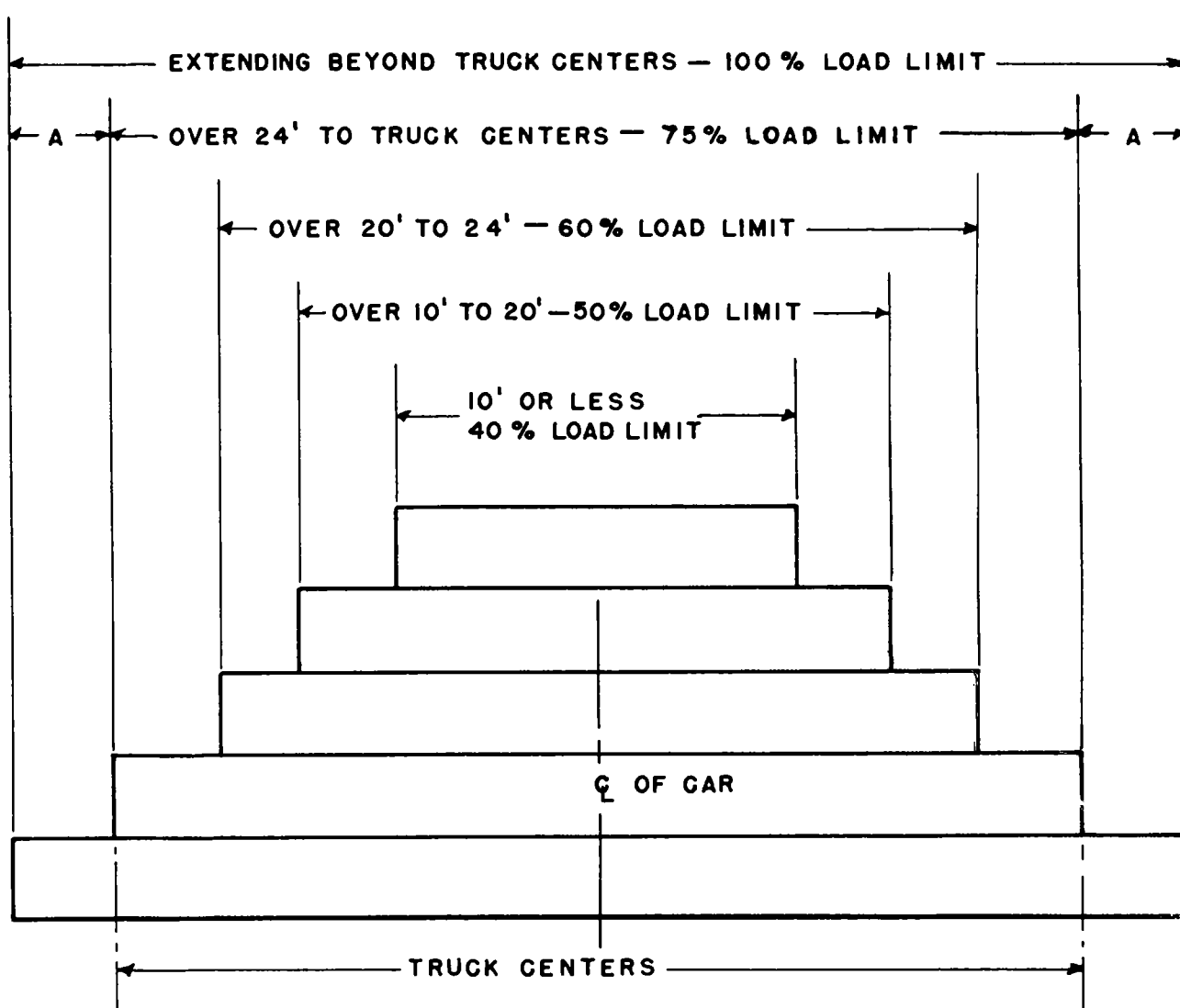


Figure 4.12—Continued



A=NOT MORE THAN 15% LOAD LIMIT BETWEEN TRUCK CENTERS AND ENDS OF CAR

Figure 4.13. Load limits for explosives.

placards to the cars. After a car is loaded, sealed, and documented, it should be moved as quickly as possible.

- (6) Railway personnel must inspect all open-top cars before movement to insure they are loaded properly and meet clearance requirements.

b. In Transit.

- (1) Transportation railway service is responsible for the security of all carload freight in transit from the time the car is moved from its loading point until it is placed at the designated unloading point.

Transportation railway service prepares all car records, train documents, and other records required to insure prompt movement and to prevent loss of cars en route. When operating conditions permit, cars containing freight subject to pilferage are grouped to permit economy in the use of guards. Special handling is given to mail or high-priority traffic of a classified nature.

- (2) Train guards are provided by military police or other units assigned or attached to Transportation railway service for

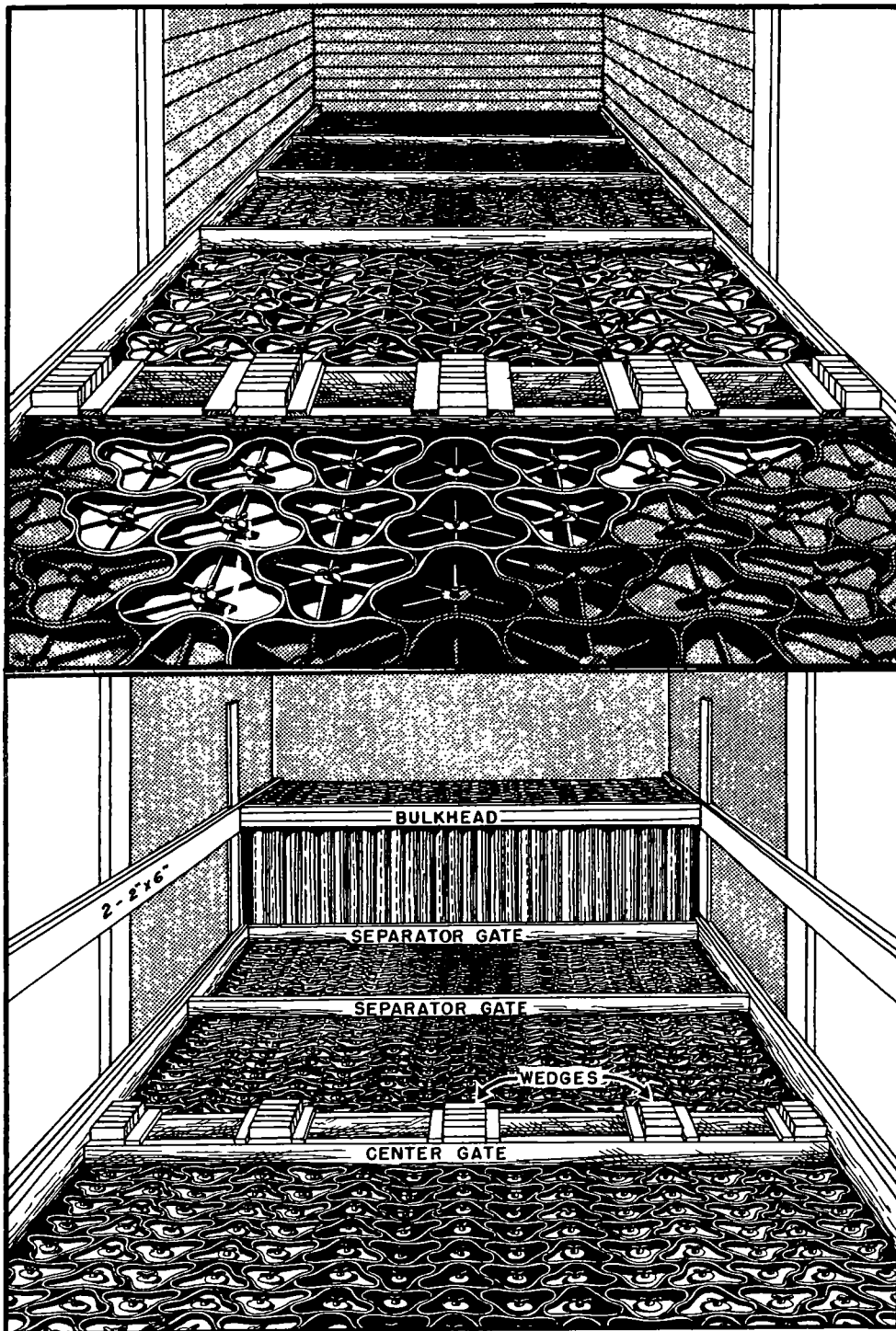


Figure 4.14. Loading and blocking ammunition in cloverleaf packages.

security duties. These units also guard cars and trains during movement in railroad yards. Sensitive supplies may be guarded by personnel assigned to the

car be the loading agency. The yard-master advises the dispatcher on receipt of cars with special guards. He also notes the receipt on the train consist that is

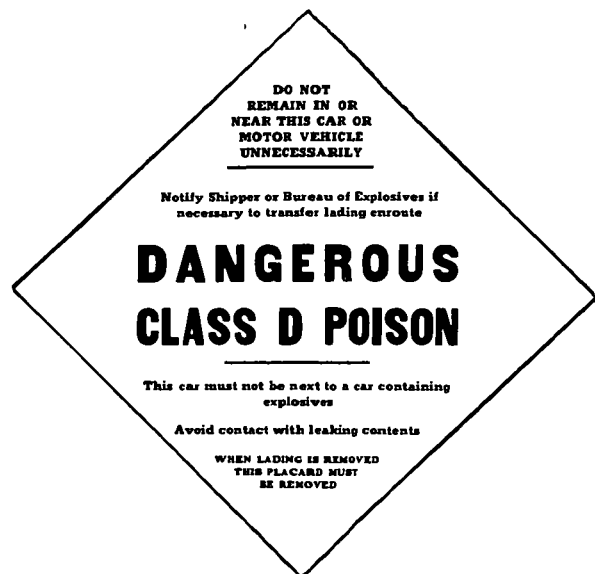


Figure 4.15. Railway car placards, United States.

transmitted to yards and terminals. This insures that all railway personnel avoid delays in transit and expedites placement at the destination.

- (3) Guard crews check car seals and inspect trains for cars that are not secure. They prepare a record, by car number, of all guarded cars in trains, noting any deficiencies or incidents en route. When relief guard takes over, the crews make a joint inspection and sign this record.
- (4) When a bad-order car containing supplies subject to pilferage is set out, a member of the guard crew should remain with the car until he is properly relieved. Guard crews must be alert at all times, par-

ticularly when the train has stopped, and when it is passing through tunnels, cuts, and villages at slow speed.

c. *At Destination.*

- (1) The consignee becomes responsible for carload freight when it is placed at the depot, siding, or track he designates. Cars should be unloaded as quickly as possible to lessen chances for pilferage.
- (2) In removing wire seals from closed cars, care must be taken to avoid breaking latches on the car door. Wire cutters are recommended for this purpose.

4.19 Troop Movements

- a. *Space Requirements.* For planning purposes,

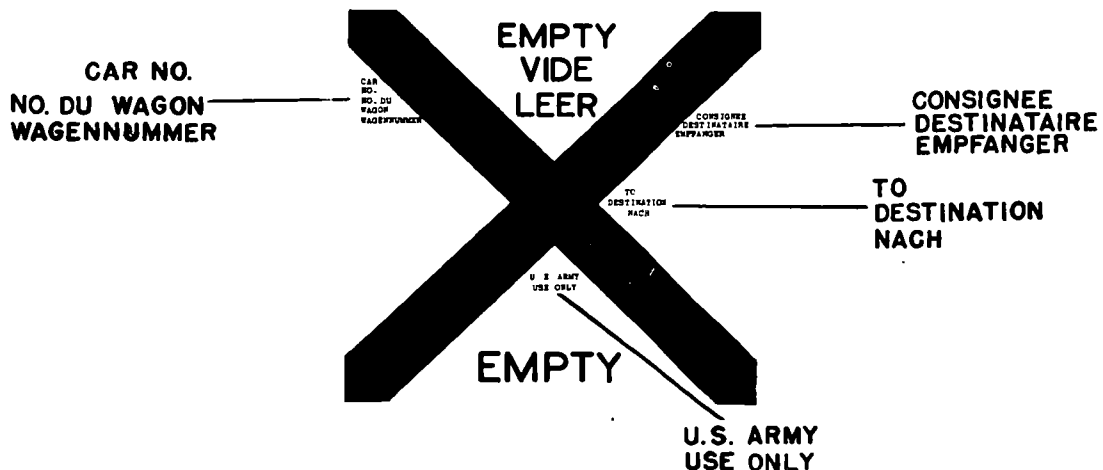
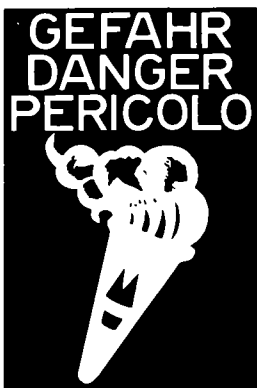


Figure 4.16. Railway car placards, U. S. Army Europe.

the following capacity data may be used when loading troops on U.S. equipment:

- (1) *Sleeping cars (average)*. Thirty-two troops with individual equipment.
- (a) Officers and warrant officers are moved

in standard pullmans, 2 per section, and are listed by number of sections; for example, 14 officers are shown as 7 sections. Officers and warrant officers of all units in one train will be grouped

in one or more pullman cars as required.

- (h) Enlisted men move in tourist pullmans, usually two per section. NCO's of the first five grades are entitled to separate berths. Space must be provided for personnel attached from medical units and men detached as guards on freight cars.
- (2) *Coaches (average)*. Fifty-five troops with individual equipment.
- (3) *Passenger trains (long-distance moves, average)*. Eleven sleeping cars, 2 kitchen cars, 1 or 2 baggage cars; 350 troops per train is typical.
- (4) *Freight trains*. For troop-unit moves, including such heavy equipment as tanks, artillery, and engineer equipment, trains seldom exceed 65 cars (650 short tons) for infantry divisions; 55 cars (1,200 short tons) for armored divisions.
- (5) *Mixed trains*. Desirable from a tactical and organizational standpoint, since they carry all personnel with their vehicles, artillery, and equipment. Not economical when passenger equipment is in short supply because they move at freight speed. In mixed trains, boxcars should be substituted for baggage cars.
- (6) *Kitchen-baggage cars*. Furnished on the basis of 1 per 250 men or fraction thereof. Requirements per train depend upon how transportation is grouped. For tentative estimates, allow one per unit.
- (7) *Flatcars*. Number required is computed on the basis of maximum utilization of each car, regardless of length. Computation is not restricted to cars of one length. Twelve inches is left clear at one end of each car for brake-wheel clearance.

b. Organizational Equipment.

- (1) Amount of headquarters, kitchen, and maintenance equipment varies somewhat in all units. For planning, allow 20 short tons per company or equivalent unit.
- (2) Organizational equipment is usually loaded in unit transportation; loading it separately requires more boxcars. Checkable baggage up to 150 pounds is carried free; generally, this is loaded in a baggage car or boxcar. When transportation groupings permit, checkable bag-

gage for two companies or similar units may be loaded in one boxcar.

c. Foreign Railways.

- (1) Few foreign railways are capable of moving complete troop units by rail at the same time the rail net is supplying a major force. Accordingly, tracked vehicles and foot troops may move by rail while wheeled vehicles with their normal towed loads move on highways.
- (2) For planning, the following capacities may be assumed:
 - (a) *Freight cars*.

Well flatcars.....	50 short tons
Medium flatcars.....	25 short tons
Small flatcars.....	12 short tons
Boxcars.....	10 short tons or 25 troops

(b) Passenger cars.

Coaches.....	40 troops
Sleeping cars.....	32 troops

4.20 Troop-Train Commanders

a. Assignment.

- (1) A troop-train commander is appointed or detailed for all troop trains. He is usually senior officer commanding troops.
 - (a) If only one unit is involved, he may be detailed by headquarters of unit ordered to move.
 - (b) If more than one unit is moving, he may be appointed by transportation movements officer.
- (2) If the troops are of mixed nationalities, the senior officer commanding troops, regardless of nationality, is troop-train commander; in cases of equal senior rank, the commander of largest number of troops served will be the troop-train commander.
- (3) He serves until journey is completed, regardless of officers boarding train en route.

b. Duties.

- (1) *Administration*. The troop train commander—
 - (a) May appoint one or more officers as assistants. When troops of other nationalities are traveling on same train, officers of the nationalities concerned are appointed as assistants.
 - (b) Complies with instructions received en route from Transportation Corps.
 - (c) Ascertains details of loading baggage, vehicles (if any), and personnel from

transportation movements officer, station master, or port commander if moving from a port.

- (d) Submits troop-movement order to transportation movements officer.
- (e) Makes location of troop-train commander's headquarters on train known to all troops.
- (f) Gives order of entrainment; directs entrainment, noting location of various units and their baggage.
- (2) *Discipline.* The troop-train commander:
 - (a) Is responsible for the protection, discipline, and conduct of all troops aboard the train.
 - (b) Directs that separate accommodations be provided for all females traveling; details an officer to any car in which separate compartments are occupied by male and female personnel to insure observance of proprieties.
 - (c) Issues orders that prohibit—
 - 1. Discussing the move with unauthorized persons.
 - 2. Detraining without orders.
 - 3. Throwing rubbish out of windows.
 - 4. Leaning out of windows.
 - 5. Damaging railway property.
 - 6. Marking or writing on sides of cars.
 - 7. Violating blackout.
 - 8. Wasting water in lavatories.
 - 9. Riding on trains except where authorized.
 - 10. Using intoxicants.
 - 11. Using train latrines while in stations.
- (3) *Sanitation.* The troop-train commander is advised by train crew of—
 - (a) Approximate time and duration of rest stops to be made during a long journey.
 - (b) Whistle signal to be used for notification of such stops.
- (4) *Air Defense.* The troop train commander will—
 - (a) Interrupt movement program only if assault is specifically directed against the destination station.
 - (b) Be prepared to assist local antiaircraft after consultation with transportation movements officer.
 - (c) Enforce blackout.
- (5) *Defense Against Ground Attack.* This will depend upon the area involved, type and degree of attack, and the forces

available to the troop-train commander. He should follow instructions and/or SOP's provided by the local commander.

4.21 Estimating Railway Capacity

a. General. Even though the amount and quality of technical information available for analysis varies, a standardized method of approach insures use of the same principles of evaluation. In general, rail capacity depends upon net division tonnage, terminal facilities, and service and repair facilities. The proper use of the procedures described below should produce data needed to estimate railway capacity.

b. Net Division Tonnage. Net division tonnage is the tonnage (short tons), or payload, that can be moved over a railway division each day. This tonnage is the sum of all net trainloads for a 24-hour period. In order to determine this sum, the analyst must make certain basic assumptions and determine each net trainload and the train density for the division.

- (1) *Basic assumptions.* A study of a capacity problem must be accompanied by a statement of the assumptions upon which the suggested solution is based. The assumptions listed below may be considered basic in solving rail capacity problems; however, conditions may necessitate the making of other assumptions. Generally, the following may be assumed.
 - (a) An adequate number of freight cars and locomotives are available.
 - (b) An adequate number of qualified personnel are available.
 - (c) All trains are freight trains or are operated at freight-train speed.
 - (d) Enemy action does not interrupt operations.
 - (e) Operations continue more than 72 hours.
- (2) *Net trainload (NTL).*
 - (a) *General.* Net trainload is the payload carried by each train. The total weight of the cars under load is the gross weight; the weight of the cars empty is tare or light weight. The difference between these two is the net load (payload) of a train. In calculating the net trainload, the analyst must consider the tractive effort (TE), gross trailing load (GTL), the length of passing sidings, and the

effect of weather. These factors are discussed below.

- (b) *Tractive effort.* Tractive effort is the horizontal force which a locomotive can exert, provided its wheels do not slip. There are two classes of tractive effort: starting TE is the effort required to start the locomotive; continuous TE is the effort required to keep it moving. Generally, a locomotive's starting TE is equal to or greater than its continuous TE. The starting TE on the level should be compared with the continuous TE required to keep the same train moving on the ruling grade, for the larger required TE controls the size of the train. Therefore, the analyst must bear in mind the ruling grade of the line. However, because of the many variables involved, the following discussion does not include the effect of the ruling grade; only level track is considered, and the starting TE is the controlling factor in determining the locomotive's pulling power. If a locomotive's TE is not furnished by a reliable source, such as the manufacturer, it can be computed by using known characteristics. Steps in computing TE are described below according to type of locomotive. (For a rule-of-thumb method, see FM 55-21.)

1. *Steam locomotive.* The effective energy at the wheel rim is reduced by friction of the piston, piston rod, cross-head, and various bearings. Steam pressure in the cylinder is always less than in the boiler, even at low speed and full cutoff. These reductions may be allowed for figuring the steam pressure (effective at the drivers) at 85 percent of the boiler pressure. The rated, or starting, TE may be determined by using the formula given below. This formula may be used with no appreciable inaccuracy up to speeds of 15 miles per hour. One of the limiting factors of tractive effort is the frictional force, or adhesion, between drivers and rail. This is a function of the weight on drivers and of the coefficient of

friction between the wheel and the rail. An average value of 0.25 is generally used for the latter; the corresponding reciprocal of the coefficient of friction is known as the factor of adhesion. A formula for determining starting TE of a steam locomotive is—

$$TE = \frac{0.85 \times P \times d^2 \times S}{D}$$

where

TE = tractive effort in pounds
 P = boiler pressure in pounds per square inch
 d = diameter of cylinders in inches
 S = length of piston stroke in inches
 D = diameter of drivers in inches

A close approximation of the starting tractive effort may be obtained by using the simple formula—

$$TE = 0.25 \times W$$

where

W = weight of the locomotive on the drivers (adhesive weight)

The adhesive weight of a locomotive can be approximated by using the following table.

Wheel arrangement of locomotive	Percent of weight on drivers	Wheel arrangement of locomotive	Percent of weight on drivers
0-4-0	100	2-8-2	73
2-4-0	80	2-8-4	61
2-4-2	57	4-8-0	80
4-4-0	67	4-8-2	67
0-6-0	100	4-8-4	57
0-6-2	75	0-10-0	100
2-6-0	86	0-10-2	83
2-6-2	87	0-10-4	71
4-6-0	75	2-10-0	91
4-6-2	60	2-10-2	77
0-8-0	100	2-10-4	67
0-8-2	80	4-10-0	83
0-8-4	67	4-10-2	72
2-8-0	89	4-10-4	62

2. *Diesel-electric locomotive.* Tractive effort curves are computed from data on generator-traction motors and auxiliaries with an overall limitation imposed by the horsepower rating of the diesel engine. These curves

are furnished by locomotive manufacturers. Whenever possible, diesel-electric locomotive TE should be obtained from these curves. If such curves are not available, starting TE can be approximated by dividing the adhesive weight of the locomotive by 3. The continuous TE can be approximated by dividing the adhesive weight by 6.

3. *Electric locomotive.* The TE for an electric locomotive is governed by the amount of power supplied to the motor and by the capability of the motor. Manufacturers of electric locomotives prepare TE curves that should be used when available. These curves are usually based on substation voltage. Because of transmission losses, it is recommended that the values taken from these curves be reduced by 10 percent. Tractive effort may also be obtained by equating work done at the rim of the driving wheels to the work produced by the motor torque in one revolution of the driving wheels. The following formula gives hourly TE; this can be considered the starting TE.

$$TE = \frac{T \times 24 \times G \times E \times N}{D \times g}$$

where

TE = tractive effort in pounds

$T \times 24$ = torque of a single motor.
(Torque is taken at a 1-foot radius from the armature shaft center.)

G = number of teeth in the driving gear

E = combined electrical and mechanical efficiency
(averages 80 to 85 percent)

N = number of motors

D = driving wheel diameter in inches

g = number of teeth in the pinion gear

Continuous TE for speeds between 5 and 10 miles per hour can be approximated by dividing the adhesive weight by 3.

- (c) *Gross trailing load (GTL).* This is the maximum weight a locomotive can pull. The GTL is affected by locomotive TE, train resistance, grade resistance, and weight of locomotive and tender. The GTL may be calculated by using the following formula:

$$GTL = \frac{TE}{TR + GR} = W$$

where

GTL = gross training load in short tons

TE = locomotive tractive effort in pounds

TR = train resistance. (This factor depends on the weight per car and the speed of the train. A resistance of 4 pounds per ton is considered an acceptable average when the speed of a train is from 5 to 15 miles per hour and the weight per car is 30 to 50 tons.)

GR = grade resistance. (This is found by multiplying 20 pounds per ton of train by the grade in percent.)

W = weight of locomotive and tender in short tons.

- (d) *Length of sidings.* The net trainload is sometimes limited by the length of the passing sidings on the line. The minimum length of passing sidings should be compared with the length of train needed to carry the planned net tonnage. To do this, estimate the average freight car length and load per car.

- (e) *Effects of weather.* Snow, ice, and freezing temperature affect locomotives and operations, thereby reducing net tonnage. For winter operations, planned net tonnage should be reduced. (A reduction may not have to be made if the net trainload has already been reduced because of the siding lengths.) See paragraph 4.22 below to determine the percent of reduction.

- (3) *Train density.* Train density is the number of trains that can be operated each way over a line in a 24-hour period. It

varies greatly on different divisions—depending upon the type of line, number and location of passing tracks, train movement control facilities and procedures, and availability of train crews, motive power, and rolling stock.

- (a) *Single-track line.* The number of trains that can be operated in one direction on a single-track line in 24 hours depends on the speed of the trains, the maximum distance between passing sidings, and the delay time spent in sidings to allow other trains to pass. Additional time must be allowed for operating delays. The relationship of these various factors is shown by the following formula:

$$N = \frac{720 \times EF}{RT + DT}$$

where

N = train density in number of trains each way per day.

RT = running time in minutes over longest distance between passing sidings on line. (Speed of train is usually considered as 10 mph—an average for war conditions. The speed might be 20 mph on an electrified line in good condition.)

DT = delay time in minutes. (This is for meeting with train from opposite direction and may vary from 0 to 15 minutes, depending on train control, switch control, etc.)

EF = efficiency factor. (This may vary from 0.5 to 0.85, depending upon type of signaling and dispatch used.) EF's for different types are: telephone and ticket, and rudimentary, 0.5; manual block, 0.6; automatic, 0.75; and centralized traffic control, 0.85.

- (b) *Double-track line.* Estimates of maximum train density on double-track lines often vary greatly because these estimates, unlike those for single-track lines, are based largely on individual judgment. Assuming the use of an

absolute blocking signal system on a double-track line, theoretically the type and interval of signals and the speed of the train are the only limiting factors. On a line that used permissive blocking, train density is limited only by the braking distance between successive trains. Visibility and speed determine the braking distance. The possible train density of a double-track line is usually greater than the number of trains that can be assembled in the yards. The efficiency factor is the same as for a single-track line ((a) above). The capacity of the yards and line may exceed the number of locomotives that can be serviced in existing facilities. Therefore, it is necessary to calculate the capabilities of yard and terminal servicing facilities for each double-track line under consideration and to select the lowest capability as the limiting factor.

c. *Terminal Facilities.*

(1) *Classification yard.*

- (a) The tonnage that can be classified and handled in a yard depends upon the total number of cars that can be held and operated in it. To estimate the tonnage capacity of a yard—

1. Determine the total trackage of the yard in feet.
2. Multiply the total trackage figure by 0.60.
3. Convert this new trackage figure to numbers of cars by dividing it by the average length in feet of the freight cars used on the line.
4. Determine the operational capability of the yard by multiplying its holding capacity in number of cars by its turnover factor. (The turnover factor, which means the number of times the holding capacity can be replaced daily, may vary from 2.0 for a hump yard with automatic facilities to as low as 0.8 for a flat yard with rudimentary operations.)

- (b) This estimated yard capability should be checked against the line capability to make sure the yard will support the line operations.

- (2) *Relay yard.* A relay yard is used to receive, service, and forward through trains; each train is kept intact. Car classification in these yards is not necessary. An appraisal must be made in each operation to determine which yards should be designated as relay yards. Operations in relay yards require an average time delay of 3 hours per train. This gives a train turnover factor of about 8 for a 24-hour period.

d. Service and Repair Facilities. The various distinctions made in classes of repair—not only worldwide but even on one railway—make it difficult to estimate the maximum capabilities of railway servicing facilities. It is necessary, however, when studying the capabilities of a railway to estimate its service and repair facilities. This problem cannot be reduced to a formula; estimates of servicing capabilities must be based largely upon good judgment and experience. For example, a 2 to 4 turnover factor in 24 hours is usual for enginehouses; servicing a locomotive requires from 6 to 12 hours. Nevertheless, the capability to provide locomotives for line operations is not determined solely by the number of hours required to service a road engine because allowance must be made for the servicing of branch line and yard locomotives also. Care must be exercised not to overestimate servicing and repair facilities when estimating maximum train density.

4.22 Miscellaneous Operational Values

a. Effect of Temperature on Hauling Power of Locomotives.

Temperature (°F.)	Loss in hauling power (percent)
Above +32	0
+31 to +16	5
+15 to 0	10
-1 to -10	15
-11 to -20	20
-21 to -25	25
-26 to -30	30
-31 to -35	35
-36 to -40	40
-41 to -45	45
-46 to -50	50

b. Average Rolling Resistance Values.

Condition of track	Pounds per ton of train
Exceptionally good.....	5
Good to fair.....	6
Fair to poor.....	7
Poor.....	8
Very poor.....	9 to 10

c. Terminal Times.

Type of locomotive	Hours
Steam.....	8
Diesel-electric.....	3

d. Requirement for Rolling Stock.

- (1) *Broad planning.* The tables in (2)(b) below shows the distribution and disposition of rolling stock for the operation of a military railway. The term “1 day’s dispatch” means the number of cars dispatched in a day from the base of operations. For broad planning purposes, the number of cars dispatched from a division terminal, railhead, etc., may be considered the same as the number dispatched from the base of operations. Therefore, 1 day’s dispatch is considered the same for all divisions of the railway in operation. In broad planning, it is also assumed that all divisions between the base of operations and the railhead will be operated at the same train density and will handle the same number of cars per train. The number of cars required is computed as follows:

- (a) Determine the value of 1 day’s dispatch by multiplying the number of cars required per train by the train density of the first division. The number of cars required per train is obtained by dividing the net trainload by the net payload of the cars to be used.
- (b) When the number of divisions and the number of cars in 1 day’s dispatch are known, the table in (2)(b) below may be used to determine the number of cars required for the operation. To this total, add 10 percent to allow for routine maintenance, bad order cars, operational peaks, etc.

(2) *Detailed planning.*

- (a) The formula below may be used for computing car requirements for each division by substituting proper values for each factor—

$$\text{No. of cars required} = \frac{\text{TD} \times 2 \times \text{CPT} \times 1.15 \times (\text{RT} \times \text{TF})}{24}$$

where

TD = train density
 2 = constant for two-way per train
 CPT = number of cars per train
 1.15 = factor for maintenance and car pool
 RT = running time (length of division divided by average speed)
 TF = time factor (switching, loading and/or unloading time)
 24 = number of hours per day

(b) Values of TF may be determined by analysis of the rail line operation under consideration using the following factors. Where loading and unloading is accomplished on the same division, increase TF by a percentage of the first and second factors given below equal to the proportion of the net division tonnage set out or filled out.

24—Division terminals having major loading points classification yards, and/or interchange facilities.

12—Division terminals having major unloading points or classification yards.

4—Intermediate terminals having no significant loading, unloading, or classification operations. (Primarily train-crew and locomotive change points or points where the gross trailing load is increased or decreased due to gradient or adjacent divisions. Local loading or unloading of cars does not exceed 10 cars per day.)

Rolling stock	
Location or type of operation	Days' dispatch required
At base of operation.....	2
Forward traffic.....	1 per division
Return traffic.....	1 per division
At railhead.....	1

e. Road Engines. The number of road engines required for operation over a given railway division may be determined by the following formula:

$$\text{Road engines required} = \text{TD} \times \frac{(\text{RT} \times \text{TT})}{24} \times 2 \times 1.20$$

where

TD = train density
 RT = running time (length of division divided by average speed)
 TT = terminal time (time for servicing and turning locomotive)
 24 = number of hours per day
 2 = constant for two-way traffic
 1.20 = constant allowing 20 percent reserve

Note. The expression $\frac{\text{RT} \times \text{TT}}{24}$ is the percent of time during a 24-hour period in which a road engine is in use and is called the engine factor. The expression provides for the pooled use of motive power which may make one or more trips per day over a short division.

f. Switch Engines.

(1) The number of switch engines required at a terminal is based on the number of cars dispatched and received, or passing through, the terminal per day. When the number of cars has been computed, that figure is applied to the table in (2) below to determine the number of switch engines required at each terminal.

(2) When the total number of switch engines required for the railway line has been computed, add 20 percent as a reserve to allow for maintenance, operational peaks, etc.

Switch engines	
Type of terminal	Number of engines
Port, railhead, loading, unloading.	1 per 67 cars dispatched and received per day.
Division.....	1 per 100 cars passing per day.

g. Fuel Requirements.

Type of locomotive	Type of operation	Estimated average rate of fuel consumption					
		Per train mile			Per hour		
		Coal (lb)	Oil (lb)	Oil (gal.)	Coal (lb)	Oil (lb)	Oil (gal.)
Steam (coal-burning):							
2-8-0, 82-ton, standard gage	Road	90			700		
2-8-0, 90-ton, standard gage		115			950		
2-8-2, 60-ton, narrow gage	Road	100			750		
Steam (oil-burning):							
2-8-0, 82-ton, standard gage	Road		55			450	
2-8-2, 60-ton, narrow gage	Road		60			500	
Diesel-electric:							
0-6-6-0, 120-ton, standard gage	Road-switcher			2.5			11.5
0-4-4-0, 60-ton, standard gage	Road-switcher			0.9			8.0
0-6-6-0, 80-ton, narrow gage	Road-switcher			1.5			10.0
0-4-4-0, 48-ton, narrow gage	Road-switcher			0.9			8.0

h. Determining Average Speed Values. For planning purposes, average speed values can be estimated by using the table below. To determine speed, select the most restrictive factor of the eight factors shown. If the restrictive factor(s) is not known, use an average speed value of 8 mph (13 kmph) for a single track and 10 mph (16 kmph) for double track. If the most restrictive factor affects only a comparatively short distance (10 percent or less) of the division, use the next higher average speed. If the average speed falls below 6 mph (10 kmph) because of the gradient, reduce tonnage to increase speed. (A 2-percent reduction in gross

tonnage increases speed 1 mile per hour.) If the ruling grade materially affects the tonnage, consider using helper service.

Restrictive factors		Average speed			
Condition of track	Percent of grade	Single track		Double track	
		mph	kmph	mph	kmph
Exceptionally good	1 or less	12	19.3	14	22.5
Good to fair	1 to 1.5	10	16.1	12	19.3
Fair to poor	1.5 to 2.5	8	12.9	10	16.1
Poor	2.5 to 3	6	9.6	8	12.9

Section IV. CONSTRUCTION, MAINTENANCE, AND SUPPLY

4.23 Construction Requirements

a. New Construction.

- (1) For planning purposes, a railroad division includes 100 principal-route miles of main line, single or double track, with its terminal operating and maintenance facilities, fueling and watering facilities, and the signaling equipment or interlocking facilities necessary for safe operation. Passing sidings on single-track lines, crossovers on double-track lines, and stations are located at intervals as required by traffic. Normally, at least one spur or siding is provided at each station. The Corps of Engineers is responsible for new rail construction and large-scale rehabilitation. Transportation personnel, however, may be required to assist

Engineer personnel in the latter work.

- (2) The following table shows the materials and net effective man-hours required for new construction of 1 mile of standard-gage (56 1/2-inch), single-track railroad.

	Short tons	Measurement tons	Man-hours
Grading, includes clearing average wooded terrain			5,000
Ballast delivered (bank run material), 5-mile (8.05-km) average haul			2,500
Track laying and surfacing, allows 400 man-hours per mile (1.61 km) for placing ties, delivered at site			3,400
Bridging: 70 linear feet (21.34 m) per mile	128	111	3,200
Culverts (7 per mile): 280 linear feet (85.34 m)	8	7	1,400
Ties: 2,900	218	300	

	Short tons	Measure- ment tons	Man-hours
Rail: 90 pound ARA-A section -	79	45	
115 pound, area section...	103	57	
Fastening (based on 39-foot (11.89 m) rail).....	33	10	
Total.....	569	530	15,500

b. Rehabilitation. The following table reflects the rehabilitation requirements that can be anticipated for a 100-mile (161-km), standard-gage, single-track division extending inland from a port, using average percentage of demolition over the entire division. For further information, see FM 55-21.

Item	Coast to 30 miles (48 km) inland					30 (48 km) to 100 miles (161 km) inland				
	Demo- lition percent	Quantity	Const materials		Const effort man-hours	Demo- lition percent	Quantity	Const materials		Const effort man-hours
			ST	MT				ST	MT	
1. Grading and ballast.....					38,200					40,500
2. Main-line trackage.....	20	9.6 km 6.0 mi	1,264	660	31,200	10	7.0 mi	2,708	1,033	36,400
3. Sidings (passing tracks) ..	80	1.9 km 1.2 km	547	437	5,800	80	2.4 mi	1,049	874	11,500
4. Station trackage.....	80	1.3 km 0.8 mi	365	291	3,800	80	1.6 mi	730	582	7,700
5. Port trackage.....	100	4.8 km 3.0 mi	1,368	1,092	14,400					
6. Railway terminal.....	75	0.75 ea	8,025	4,875	160,000					
7. Culverts.....	15	32.0 ea	27	27	5,800	15	74 ea	63	63	13,700
8. Bridging (70 ft per mile) ..	75	480 m 1,575'	1,575	1,500	46,200	55	2,700 ft	2,700	2,672	70,000
9. Water station.....						100	3 ea	135	210	9,000
10. Fuel platform.....						100	1 ea	19	16	900
11. Totals.....			13,171	8,882	305,400			7,404	5,450	189,700

4.24 Maintenance Responsibilities

a. After railways are constructed and turned over to the transportation railway service for operation, minor railway maintenance in the communications zone and in the combat zone to the forward limit of traffic is the responsibility of the transportation railway service.

b. The transportation railway service is responsible for the maintenance of the railway communications circuits that are used exclusively for the operation and administration of the railways. This responsibility becomes effective when all the circuits on the line have been turned over to the transportation railway service for administration and operation. The transportation railway service is responsible for the operation and for the organizational and field maintenance of railway block signals, of interlocking plants, and of centralized traffic control devices. It is also responsible for the installation, maintenance, and operation of organizational communications within railway groups, battalions, and lower echelon units.

c. The transportation railway system is normally divided into a number of divisions for maintenance and operation. Each division is assigned a railway operating battalion; each battalion in-

cludes personnel from the railway engineering company to perform necessary maintenance of tracks and structures.

d. The battalion commander has overall responsibility for railway maintenance, including maintenance work, instructions, and procedures. The company commander of the railway engineering company is maintenance-of-way superintendent and is directly responsible for the maintenance of tracks and structures, for the proper supervision of all maintenance work and procedures, and for the necessary inspection of track and structures on the division. Platoon and section leaders are charged with the proper supervision of assigned maintenance operations.

4.25 Maintenance Categories

a. General. Army maintenance is divided into three categories and five echelons: organizational (first and second echelon), field (third and fourth echelon), and depot (fifth echelon).

b. Locomotives.

- (1) First echelon maintenance consists primarily of preventive maintenance and includes inspection of visible moving parts, lubrication, and making minor adjustments. The rail equipment com-

pany of the operating battalion performs first echelon maintenance before and after operations. During operations, first echelon maintenance is the responsibility of the train operating company of the operating battalion.

- (2) Second echelon maintenance consists of preventive maintenance which includes repair or removal of parts whose condition might interfere with the efficient operation of the equipment. The railway equipment company of the operating battalion is responsible for second echelon maintenance and the accomplishment of required records and reports.
- (3) Third echelon maintenance repairs are performed by the mobile railway workshop in the forward area and by the railway equipment company of the operating battalion in the rear areas. When the repairs are not too extensive, the locomotive is repaired and put back into service. If the repairs are beyond the capabilities of the railway equipment company and the mobile railway workshop, only those repairs will be made that are necessary to move the locomotive to a fixed installation for repair.
- (4) Fourth and fifth echelon maintenance is normally performed by the transportation railway shop battalion. In a theater of operations, it may be both feasible and necessary for some heavy maintenance to be performed by the transportation railway operating battalion.
- (5) On diesel-electric locomotives, maintenance by the railway operating battalion includes making periodic inspections (using DD Form 1336), running repairs, and current reports of inspections and repairs. The transportation railway operating battalion does not attempt to replace major parts, such as diesel engines and main generators, unless directed by proper authority. Components, such as air compressors and auxiliary generators, may be replaced.

c. Rolling Stock.

- (1) Normally the railway operating battalion's train maintenance sections and crews perform the first three echelons of repair; this includes running repairs and inspection of rolling stock. The railway

shop battalion is responsible for fourth and fifth echelon maintenance. Fourth and fifth echelon repairs usually require over 40 man-hours of labor per car.

- (2) First echelon maintenance is performed by car inspectors at the train originating point and at inspection points en route to insure safe movement of the car and its lading.
- (3) Second echelon maintenance is performed at the originating point of the train and at inspection points en route by military car inspectors or civilian railroad personnel. It consists of making running repairs necessary for the safe operation of freight equipment and the safe and comfortable operation of passenger cars. Second echelon repair does not require taking cars out of service.
- (4) Third echelon maintenance is performed by maintenance personnel, either military or civilian, at the home terminals of the cars or at a prescribed location. It consists of running and emergency repairs that necessitate taking the car out of service for a short time.
- (5) Repair-track installations (rip tracks) are normally set up at main terminals. They are also usually necessary at other points on the division, such as junction points or heavy loading centers, to take care of repairs that cannot be made at the loading installation and to avoid moving the cars into the main terminal. The master mechanic (railway equipment company commander) is responsible for the operation of the repair-track installation.

4.26 Inspection and Maintenance of Steam Locomotives

a. Basic Principles.

- (1) Suitable inspection pits and facilities must be provided for inspection, repair, and adjustment of parts.
- (2) The engineer is responsible for the equipment he operates; this responsibility is primarily first echelon.
- (3) The fireman is responsible for maintaining the proper water level and steam pressure. He receives instructions from the engineer, his immediate superior.
- (4) Each locomotive must be inspected daily,

or at the end of each trip, and DA Form 55-226 must be completed.

- (5) Each locomotive must be inspected monthly, and DA Form 55-227 completed.
- (6) In addition to the daily and monthly inspections, each locomotive must be inspected quarterly, semiannually, and annually (DA Form 55-228).

b. Enginehouses. The two general types of enginehouses are turnaround and maintenance. The turnaround enginehouse is small and is only equipped with facilities for performing minor repairs and services. Work done in this enginehouse usually requires only 1½ to 3 hours. The maintenance enginehouse has facilities for making major as well as minor repairs; here the division locomotives are maintained in good operating condition and kept at maximum availability.

4.27 Maintenance-of-Way

a. Roadway. Roadway maintenance is the care taken and work performed to keep that part of the right-of-way on which the track is constructed in good condition. Right-of-way includes excavations, embankments, slopes, shoulders, ditches, and diversions of roads and streams.

b. Track. In a theater of operations, the track must be maintained in operable condition at all times. The four primary considerations in track maintenance are gage, surface, alinement, and dress. The roadbed and track must be inspected frequently to avoid delays in operation resulting from damage caused by sabotage, direct enemy action, or weather.

c. Structures. In a theater of operations, the structures essential to the railway operation must be maintained in accordance with the standard maintenance prescribed. Structures include bridges, culverts, tunnels, and fueling and watering facilities. When repairing structures, minimum clearances must be observed at all times.

4.28 Degree of Curvature and Curve Radius

The table below shows relationships between degree of curvature and radius of curvature for simple curves. Degree of curvature means the degrees of central angle subtended by a 100-foot (30.48 meters) chord. Radius of curvature is the distance from the apex of the central angle out to the curve. The degree of curvature and radius of curvature form the sector of a circle; the area of

this sector may be expressed in either of the following ways—

$$\begin{aligned} \text{Area} &= \frac{R \times \text{arc}}{2} \\ &= \frac{3.1416 \times R^2 \times D}{360} \end{aligned}$$

Equating the two expressions above,

$$\begin{aligned} R &= \frac{\text{arc} \times 360}{2 \times 3.1416 \times D} \\ &= \frac{\text{arc} \times 57.3}{D} \end{aligned}$$

where

R = radius of curvature in feet

D = degree of curvature in degrees

For a 1° curve, the arc and chord are almost the same. Therefore, for practical purposes the arc in the formula for R above can be called a 100-foot chord for a C value of 1°. R then equals 5730 for a 1° curve, and $\frac{5730}{D}$ for a D-degree curve.

D	R	D	R	D	R	D	R
1	5730	8	716	15	382	22	261
2	2865	9	637	16	358	23	249
3	1910	10	573	17	337	24	239
4	1433	11	521	18	318	25	229
5	1146	12	478	19	300	26	220
6	955	13	441	20	286	27	212
7	819	14	409	21	273	28	205

4.29 Curve Resistance

Curve resistance is the resistance offered to motion along a curved track in excess of that offered by a straight track. Curve resistance is developed in terms of pounds per ton of train. A constant factor of 0.8 pound per ton of train for each degree of curve is used in all capacity determination formulas. The continual passing of trains around a curve eventually moves the track, which disturbs alinement and distorts the curve. The track should be restored to its correct curvature after determining if any distortion exists. This should be done by Corps of Engineer personnel. A field expedient for determining the curvature of a track is the string method (par. 4.30).

4.30 Determining Curvature by String Method (fig. 4.17)

If a surveying instrument is not available, the degree of simple curvature (arc of a circle) of a track may be computed by the string method. Although this method is not an absolutely exact one because of the uncertainty of how much the string used has stretched, the degree of error is insignificant. To determine the degree of curvature of a track by the string method—

a. Select a portion of track well within the main body of the curve.

b. Measure a chord-distance of 62 feet (18.897 meters) along the inside ($\frac{5}{8}$ " down from the top) of the high rail (A to B, fig. 4.17).

c. Stretch a string or strong cord very tightly between points A and B, and measure the distance M at the midpoint of the cord. The distance in inches is approximately equal to the degree of curvature. In the example shown in figure 4.17, if M is 5 inches, the degree of curvature is 5°. (As a curve gets sharper, the distance M increases. A 10° curve is sharper than a 5° curve when the chord-distance remains constant.)

4.31 Grade Resistance

Grade resistance is the resistance to the progress of a train on an incline, caused by the force of gravity which tends to pull the train back downhill. Expressed in pounds per ton of train, grade resistance is obtained by multiplying the grade percentage by 20. Grade percentage is obtained by dividing the vertical rise in feet by the horizontal distance travelled in feet and then multiplying the dividend by 100.

4.32 Rolling Resistance

Rolling resistance is brought about by friction between the rails and wheels, undulation of track under a moving train, internal friction of rolling stock, and the resistance of still air. The amount of resistance depends to a large extent upon track condition and varies between 5 and 10 pounds per ton of train.

4.33 Railway Supply

a. Railway supplies, as distinguished from organizational supplies, are expendable supplies required for the operation and maintenance of railway divisions.

b. Whenever possible, local sources of supply should be used to ease transportation requirements. In a theater of operations, supplies may be procured from military stocks, manufacturers that are in or near the theater, foreign railways, captured enemy material and equipment, parts and assemblies manufactured or repaired by the railway shop battalion, and transfers from other railway operation units.

c. All operating units must submit reports of supplies on hand at the beginning of operations to facilitate supply control.

d. The battalion supply officer serves as fuel agent for the railway transportation operating battalion; he is responsible for the operating agencies of the transportation railway service receiving sufficient locomotive fuel—regardless of source. Requisitions for fuel and lubricants are made through normal supply channels.

e. Tables of allowances and supplies are prepared by the supply officer of the highest transportation railway echelon for all units within the command. A workable stock level allowance must be determined for each unit to insure uninterrupted operation at all times. Normally, stock levels for the railway division are determined from past requirements.

f. An estimate of spare parts requirements may be made by using the factor of 1.5 short tons per month for each train per day moving in either direction. Beginning with the first railway division, select the train density established for the division, and multiply by 2 (for two-way travel); then multiply this result by 1.5, which equals the total amount in short tons of spare parts required per month for this specific division. Continue this process for each successive division to determine the grand total of short tons required per month for the entire railway. This is an estimate only.

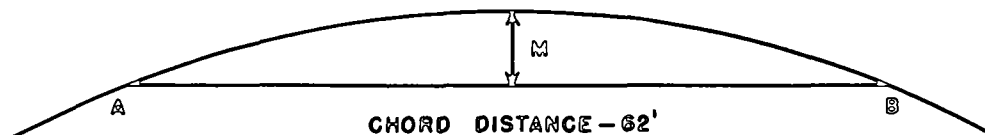


Figure 4.17. Determination of degree of curvature, using the string method.

Revisions are necessary based on operating conditions.

4.34 Transportation Depot Company

The basic organization for supply in the Transportation Corps is the transportation depot company. Its mission is to provide for the receipt, storage, and issue of all Transportation Corps items of supply and equipment.

4.35 Requisition Procedure

a. The normal procedure for requisitioning a Transportation Corps item of supply is as follows. The company commander submits a request to the battalion supply officer. The battalion supply officer consolidates requests, makes lateral transfers of transportation supplies when necessary, prepares a formal requisition, and forwards it to the railway group supply officer. The supply officer of the railway group determines if the item or items requested are available in one of the other units assigned to the railway group. The item or items are transferred if they are available; if they are not available, the requisition is processed and forwarded to the assistant general manager, supply (G4). The assistant general manager, supply, may then direct the transfer of the requisitioned item or items from one railway group to another. If the items cannot be obtained from another railway group, he passes the requisition to the transportation depot company for issue. If no depot company is assigned to the transportation railway service, the requisition is forwarded to the proper supply agency.

b. When the railway group is the highest echelon of the transportation railway service in the theater, the group supply officer discharges the responsibilities of the assistant general manager, supply. When the railway operating battalion is not operating as a part of a railway group, the bat-

talion supply officer is authorized to handle supply matters directly with supply agencies. The highest transportation railway service headquarters in the theater may authorize the battalion supply officer to requisition certain transportation items of routine supply directly from the transportation depot company without the approval of the next higher echelon. Items in short supply may be controlled as necessary, depending on the stock level in the depot. The battalion supply officer may be permitted, by the same headquarters, to requisition routine items from the depots of the other technical services.

c. The railway group may authorize the operating battalion supply officer to deal directly with the railway shop battalion for parts and assemblies manufactured or repaired by the railway shop battalion.

d. To obtain supplies from outside sources—industry, railway stocks, and railway supply channels—the battalion supply officer prepares purchase orders or requisitions in accordance with the policy established in the particular theater. Normally, purchase orders or requisitions are forwarded to the railway group supply officer for further action; however, the railway operating battalion commander may be delegated the authority to approve purchase orders and requisitions for specified quantities of particular supplies. In such cases, the battalion procures the supplies locally and sends information copies of the transaction to the railway group supply officer. When the company commander is authorized to make local purchases, information copies of each transaction must be sent to the battalion supply officer. It is essential that accurate records be maintained of all transactions in order to protect the U.S. Government from fraudulent claims.

e. All captured enemy material and equipment must be recorded and accounted for.

CHAPTER 5

TERMINAL AND WATER TRANSPORT

Section I. TERMINAL ORGANIZATION

5.1 Terminal Units: Capabilities and Assignment

<i>Unit</i>	<i>TOE</i>	<i>Mission and/or capability</i>	<i>Assignment</i>
Headquarters and headquarters company, terminal command A.	55-131	Supervises and directs units required in— Beach operations: working up to 4 ships, unloading up to 86,000 ST cargo and debarking 25,000 personnel; or loading up to 60,000 ST cargo and embarking 12,500 personnel per month. Wharf operations: working up to 6 ships, unloading up to 130,000 ST cargo and debarking 37,500 personnel; or loading up to 90,000 ST cargo and embarking 18,750 personnel per month.	Normally to a logistical command or other appropriate command in a theater of operations.
Headquarters and headquarters company, terminal command B.	55-121	Supervises and directs units required in— Beach operations: working from 5 to 8 ships, unloading 108,000 to 172,000 ST cargo and debarking 50,000 personnel; or loading 75,000 to 120,000 ST cargo and embarking 25,000 personnel per month. Wharf operations: working from 7 to 12 ships, unloading 151,000 to 260,000 ST cargo and debarking 75,000 personnel; or loading 105,000 to 180,000 ST cargo and embarking 37,000 personnel per month.	Normally, to a logistical command or other appropriate command in a theater of operations.
Headquarters and headquarters company, terminal command C.	55-111	Supervises and directs units required in— Beach operations: working from 9 to 16 ships, unloading from 194,000 to 346,000 ST cargo and debarking 100,000 personnel; or loading from 135,000 to 240,000 ST cargo and embarking 50,000 personnel per month. Wharf operations: working from 13 to 24 ships, unloading from 280,000 to 520,000 ST cargo and debarking 150,000 personnel; or loading from 195,000 to 360,000 ST cargo and embarking 75,000 personnel per month. Other terminal operations: unloading, or transferring from one mode to another, 280,000 to 520,000 ST cargo and debarking 150,000 personnel; or loading 195,000 to 360,000 ST of cargo and embarking 75,000 personnel per month.	Normally, to a logistical command or other appropriate command in a theater of operations.
Headquarters and headquarters detachment, transportation terminal battalion.	55-116	Commands and provides administrative supervision of— Four company-size units. Any combination, not exceeding equivalent of 4 companies, of terminal service companies, boat companies, harbor craft units, staging area companies, and amphibian companies.	Normally attached to a terminal command, a logistical command, or an engineer amphibious support command, but may operate separately under the supervision of the appropriate staff transportation officer.
Transportation terminal service company.	55-117	At an established terminal or in a beach operation can— Discharge 1 ship at rate of 720 ST general cargo daily,	Normally to a terminal battalion or a terminal command, but may operate separately under the su-

<i>Unit</i>	<i>TOE</i>	<i>Mission and/or capability</i>	<i>Assignment</i>
		or Load 1 ship at rate of 500 ST general cargo daily, and Sort cargo by technical service and load cargo on initial mode of transport from wharf and/or at waterline in beach operation, and Prepare transportation documents for all cargo loaded or unloaded, and Account for cargo handled. When operating at reduced strength, can discharge 360 ST cargo or load 250 ST cargo daily (working one 5-hatch ship) and clear unloading site of equivalent tonnages. When reinforced with other modes of transport and other technical and administrative services, can conduct terminal operations at an isolated location involving discharge of 1 ship at the rate of 720 ST cargo per day.	pervision of the appropriate staff transportation officer.
Headquarters and headquarters company, transportation boat battalion.	55-126	To command, administer, and supervise operations of transportation units engaged in movement of personnel and cargo in Army water terminal operations and Army waterborne tactical operations and to augment naval craft in joint amphibious operations.	To a communications zone or logistical or other appropriate command in a theater of operations. May be attached to a terminal command, a logistical command, or an engineer amphibious support command; may operate separately under appropriate staff transportation officer.
Transportation light boat company.	55-127	Transports 1,440 ST of general cargo daily in logistical over-the-shore operations with each of the 24 available landing craft making 4 round trips with an average load of 15 ST each. With 32 landing craft available, the maximum one-time lift capability for cargo having a high density is 1,088 ST cargo or 3,840 combat-equipped troops for a 7-hour trip.	Normally assigned or attached to a boat battalion, a terminal battalion, a terminal command, a logistical command, or an engineer amphibious support command.
Transportation medium boat company.	55-128	Based on maintenance factor of 25 percent, provides 12 task LCM(8)'s daily for sustained 24-hour, day-to-day operations. With 12 landing craft available, transports daily— 2,400 ST of outsize, heavy lifts, based on an average load of 50 ST per landing craft, each craft making 4 round trips. 720 ST of general cargo, based on an average load of 30 ST per craft, each craft making 2 round trips. With 16 task landing craft available, the maximum one-time lift capability with high density cargo is 960 ST or 3,200 combat-equipped troops for short distances.	Normally assigned or attached to a boat battalion, a terminal battalion, a terminal command, a logistical command, or an engineer amphibious support command.
Transportation heavy boat company.	55-129	Transports an average of 16,000 troops with individual equipment, or 2,160 ST vehicles, or 6,000 ST tanks.	Normally assigned or attached to a boat battalion, a terminal command, a

<i>Unit</i>	<i>TOE</i>	<i>Mission and/or capability</i>	<i>Assignment</i>
		Transports an average of 1,440 ST general cargo.	logistical command, or an engineer amphibious support command.
		Transports in a one-time maximum lift 1,800 ST cargo or 4,800 troops with individual equipment.	
Transportation amphibious truck company.	55-137*	At full strength, operating two 10-hour shifts, transports an average of 720 ST cargo daily assuming availability of 30 vehicles, each vehicle carrying 3 tons per trip and making 8 trips per day.	Normally, to a terminal battalion, but may operate separately under the supervision of an appropriate staff transportation officer.
Transportation light amphibian company.	55-138	Transporting daily, in two 10-hour shifts, an average of 1,080 ST general cargo, with an average availability of 27 amphibians, each carrying 4.5 tons per trip and averaging 9 trips per day. Transporting in a one-time emergency lift 170 ST general cargo, based on 34 amphibians carrying 5 tons each.	To a logistical command. May be attached to a terminal command or a terminal battalion or may operate separately under the supervision of the appropriate staff transportation officer.
Transportation medium amphibian company.	55-139	At full strength, operating two 10-hour shifts, transports an average of 1,080 ST cargo daily, assuming availability of 19 LARC-15's, each carrying 10.2 tons per trip and making 5-6 trips per day.	Normally, to a logistical command. May be attached to a terminal command or terminal battalion or may operate separately under the supervision of an appropriate staff transportation officer.
Transportation heavy amphibian company.	55-140	At full strength, operating two 10-hour shifts, transports an average of 1,800 ST heavy vehicles and equipment or 7,200 combat-equipped troops daily, assuming availability of 12 BARC's, each carrying 30 tons or 120 personnel per trip and making 5 trips per day.	Normally to a logistical command. May be attached to a terminal command. Platoons may be attached separately to terminal battalions.
Transportation staging area company.	55-147	Provides mess and billeting for 7,500 troops in units daily. Operates 5 dispersed staging areas, each capable of staging an infantry battle group or its equivalent.	Normally, to a terminal command or logistical or area command.
Transportation floating craft depot maintenance company.	55-157	Provides depot maintenance on a 24-hour basis for approximately 100 self-propelled craft and all associated nonpropelled craft.	Normally, to a terminal command.
Transportation amphibian general support company.	-----	To provide field maintenance support for amphibians.	To a terminal command or terminal battalion or may operate separate under the supervision of an appropriate staff transportation officer.
Floating craft crews, floating craft maintenance teams, terminal service teams.**	55-500 and 55-510	Provides personnel and equipment for the following purposes— To supplement TOE organizations where additional trained personnel are required in numbers less than TOE strength. To perform transportation functions as part of a larger organization where the need for the activity is less than a similar TOE organization. To form an organization where no TOE unit	Teams may be attached or assigned as required to higher echelon units or may be organized into service units to perform functions as required by existing conditions.

* Amphibious trucks will be deleted from Army inventory and all units organized under this TOE are scheduled for elimination from the active Army troop list by the end of fiscal year 1964, and TOE 55-138, TOE 55-139, and TOE 55-140 are scheduled to replace this TOE.

** See TOE 55-500 and TOE 55-510 for additional teams.

is provided or where a number of small cells of diversely trained personnel are required for the proper functioning of an organization.

5.2 Assigned or Attached Units

Terminal commands may have any combination of these units assigned or attached as required to perform their mission.

a. Transportation Units.

TOE	Unit
55-16	Headquarters and Headquarters Detachment, Transportation Truck Battalion.
55-17	Transportation Light Truck Company.
55-18	Transportation Medium Truck Company.
55-19	Transportation Car Company.
55-28	Transportation Heavy Truck Company.
55-116	Headquarters and Headquarters Detachment, Terminal Battalion.
55-117	Transportation Terminal Service Company.
55-126	Headquarters and Headquarters Company, Transportation Boat Battalion.
55-127	Transportation Light Boat Company.
55-128	Transportation Medium Boat Company.
55-129	Transportation Heavy Boat Company.
55-137	Transportation Amphibious Truck Company.
55-138	Transportation Light Amphibian Company.

TOE

Unit

55-139	Transportation Medium Amphibian Company.
55-140	Transportation Heavy Amphibian Company.
55-147	Transportation Staging Area Company.
55-157	Transportation Floating Craft Depot Maintenance Company.
55-158	Transportation Amphibian General Support Company.
55-500	Transportation Service Organization.

b. Other Units.

TOE

Unit

5-129	Engineer Port Construction Company.
5-500	Engineer Service Organization.
8-500	Medical Service Organization.
9-348	Ordnance Motor Vehicle Assembly Company, Communications Zone.
9-500	Ordnance Service Organization.
10-67	Quartermaster Service Company.
10-500	Quartermaster Service Organization.
11-500	Signal Service Organization.
12-605	Army Postal Unit, General Assignment.
14-500	Finance Service Organization.
19-55	Military Police Battalion.
19-57	Military Police Company.

Section II. VESSEL CHARACTERISTICS AND DATA

5.3 Transportation Unit Floating Craft

Type of vessel	Designation	Length	Beam	Light displacement (LT)	Maximum draft (aft)	Fuel capacity (gal.)	Fuel consumption (gal. per hour)	Speed, loaded (knots)	Cruising range, loaded (nautical miles)	Crew	Capacity	
											Cargo	Passengers
Supply, diesel, steel, 176', design 381.	FS ¹	176' 6"	32'	465	12'	21,000	69	12.5	3,800	24	340 LT 21,462 cu ft	9 berth 75 deck
Dry cargo, SP, diesel, steel, 210', design 7013.	FS ²	222' 9½"	38'	1,068	14' 6"	54,100	96	12	6,750	32	1,260 LT 56,400 cu ft	
Liquid cargo, SP, diesel, steel, 210', design 7014 (fig. 5.1).	Y	222' 9½"	38'	797	17'	58,670	96	12.7	7,700	29	462,000 gal.	
Refrg cargo, SP, diesel, steel, 210', design 7015.	FSR ²	222' 9½"	38'	1,246	15'	62,000	96	12	7,700	29	1,000 LT 40,920 cu ft	

¹ Obsolescent, nonstandard.

² Prototype, nonstandard.

5.4 Boats

Type of boat	Designation	Length	Beam	Light displacement (LT)	Maximum draft (aft)	Fuel capacity (gal.)	Fuel consumption (gal. per hour)	Speed, loaded (knots)	Cruising range, loaded (nautical miles)	Crew	Capacity		Remarks
											Cargo	Passenger	
Utility, diesel, plastic, 26', design 6009.	J ¹	26' 6"	8' 1"	3.04	4'	80	4	10	200	2	1 LT	12 to 15	Can be transported in cradle on freight vessels.
Picket, diesel, wood, 36' 6", design 234-B.	J ¹	36' 6"	10' 7"	6	4'	300	10	15	450	4	-----	-----	Can be crated and stowed on deck or in hold of freight vessel. Bow reinforced for beaching.
Picket, diesel, steel, 46', design 4003 (fig. 5.2).	J	46' 4½"	12' 3"	9.8	3' 6"	370	18	16	328	3	-----	-----	Replaces design 234-B.
Picket, diesel, wood, 65', design 4002 (fig. 5.3).	Q	64' 11"	15' 11"	31	6'	900	25	14	500	6	4 LT	5	Replaces design 416.
Passenger and cargo vessel, steel, 65', design 2001 (fig. 5.4).	T	65' 6"	17' 8"	66	7'	1,150	19	10.5	635	4	24 LT 1,800 cu ft	24	Normally deckloaded on large cargo ship. Under good conditions, can proceed overseas under own power.

¹ Obsolescent, nonstandard.

5.5 Tugs

Type of tug	Designation	Length	Beam	Light displacement (LT)	Maximum draft (aft)	Fuel capacity (gal.)	Fuel consumption (gal. per hour)	Speed w/o tow (knots)	Cruising range (nautical miles)	Crew	Remarks
Harbor, diesel, 200-hp, steel, 45', design 320.	ST	45' 2 1/4"	12' 5 1/4"	25.2	6'	900	12	10	750	5	Capable of short ocean passages under own power. Normally transported overseas on larger vessel.
Harbor, diesel, 600-hp, steel, 65', design 3004.	ST	70'	19' 6"	100	8' 3"	5,850	41	12	1,700	5	
Harbor, diesel, 1,200-hp steel, 100' design 3006.	LT	107'	26' 6"	295	12' 2"	20,768	83	12	3,000	16	
Oceangoing, diesel-electric, 1,530-hp, steel, 143', design 377-A.	LT ¹	143' 5"	33'	566	14'	58,131	130	11.5	5,100	46	Can move overseas under own power.

¹ Obsolescent, nonstandard.

5.6 Floating Cranes

Type of crane	Designation	Length	Beam	Light displacement (LT)	Maximum draft (aft)	Fuel capacity (gal.)	Fuel consumption (gal. per hour)	Crew	Cargo handling equipment
Barge, diesel-electric, revolving, steel, 60 LT, design 413-D (fig. 5.5).	BD	142'	58'	1,000	5' 6"	1,350	16	8	Main hoist capacity: 60 LT Main hoist radius: 73' Aux. hoist capacity: 15 LT Aux. hoist radius: 100'
Barge, diesel-electric, revolving, steel, 89 LT, design 264-B (fig. 5.6).	BD	140'	70'	1,407	6'	15,000	25	14	Main hoist capacity: 89 LT Main hoist radius: 80' Aux. hoist capacity: 15 LT Aux. hoist radius: 122' 6" Aux. reach below waterline: 25'.

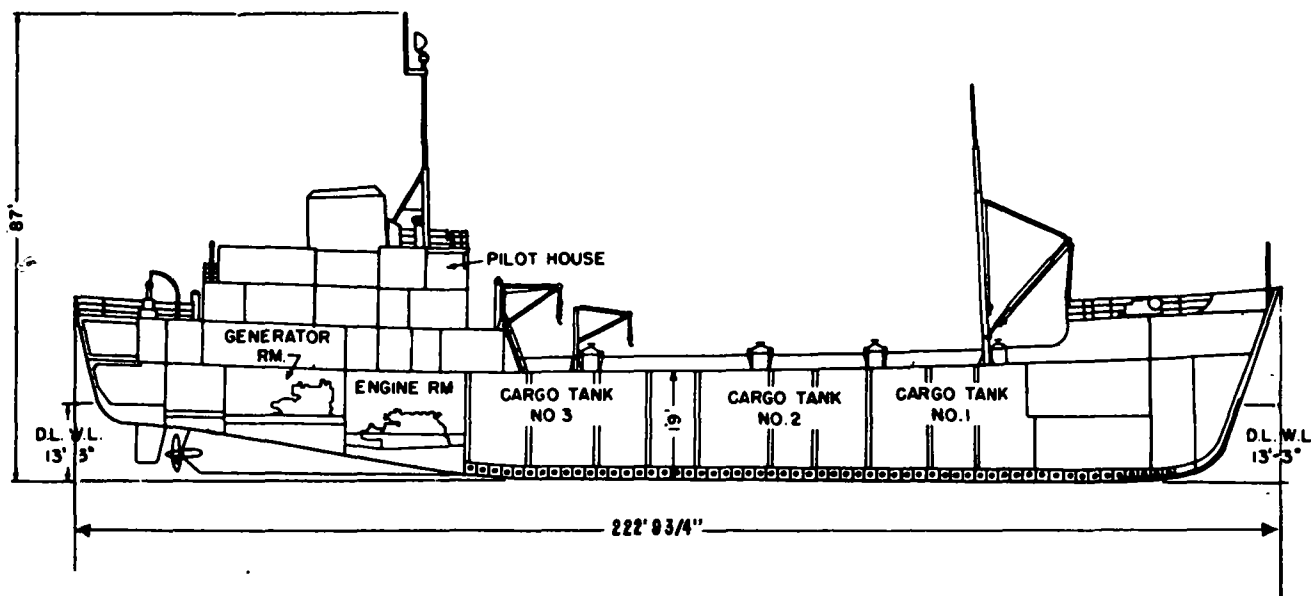


Figure 5.1. Vessel, liquid cargo, diesel, steel, 11,500 barrels, 210 feet, design 7014.

5.7 Self-Propelled Barges

Type of barge	Designation	Length	Beam	Light displacement (LT)	Maximum draft (aft)	Fuel capacity (gal.)	Fuel consumption (gal. per hour)	Loaded speed (knots)	Cruising range (nautical miles)	Crew	Cargo capacity (LT)	Remarks
Liquid-cargo, self-propelled, diesel, steel, 6,500 bbl, 182', design 294-A.	BSP ¹	182' 6"	30'	476	11' 6"	10,946	43	8	2,000	17	Dry: 49, Liq: 770 (273,000 gal.)	Can push 3 hopper barges (55') loaded to 5' 6" at 8 knots. Can be disassembled for rail shipment.
Inland waterways, self-propelled, diesel, steel, 55', design 3011.	BPSI ¹	56' 2"	15'	42	5' 6"	1,750	22	8	675	3	20	

¹ Obsolescent, nonstandard.

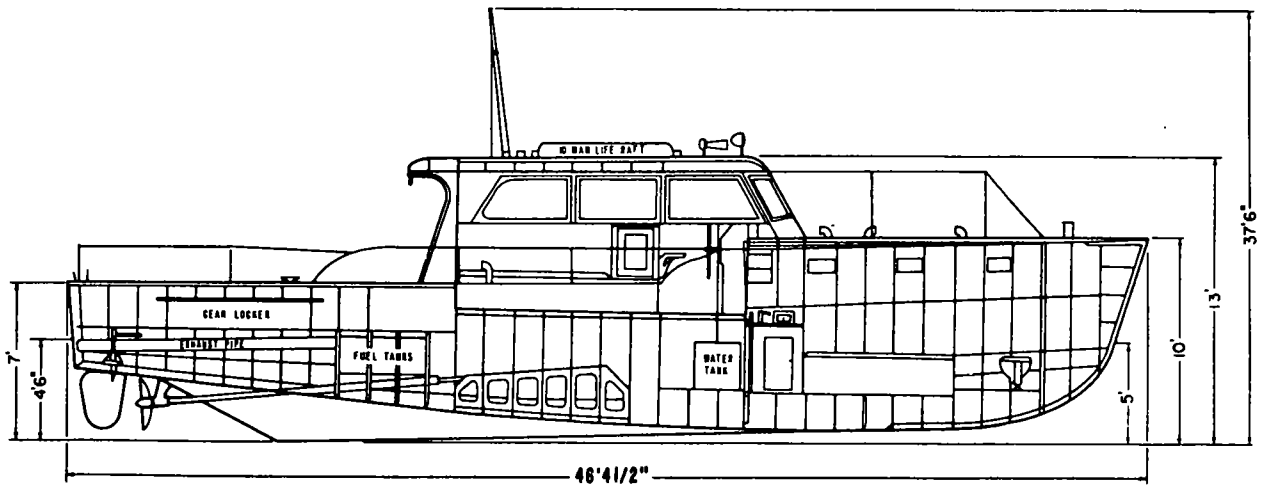
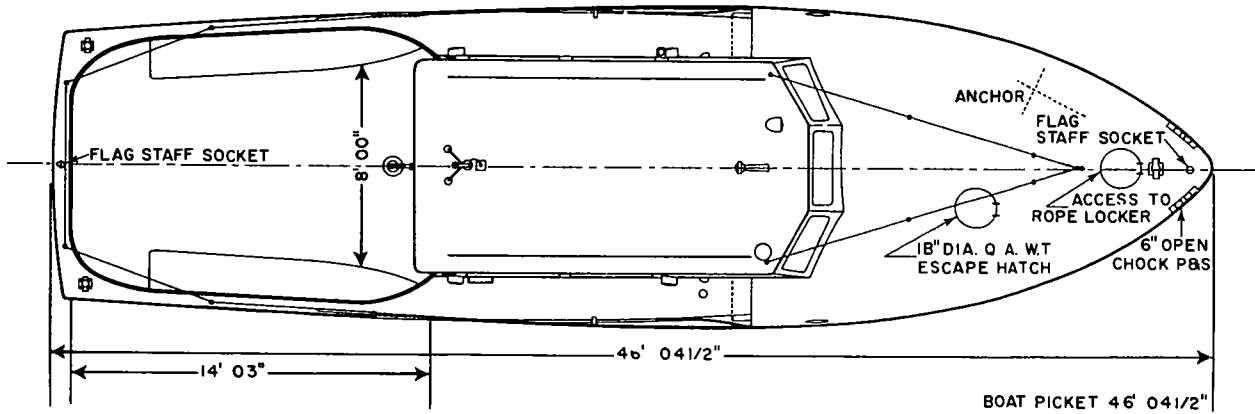


Figure 5.2. Boat, picket, steel, 46 feet 4 1/2 inches.

5.8 Nonpropelled Barges

Type of barge	Designation	Length	Beam	Light displacement (LT)	Maximum draft (aft)	Crew	Cargo capacity	Remarks
Deck cargo, nonpropelled, steel, 570 tons, 110', design 7005 (fig. 5.7).	BC	110'	32'	120	8'	NA	570 LT	Conversion kit 7006 makes it into a covered barge. Can towed overseas.
Deck cargo, nonpropelled, steel, 585 tons, 120', design 231-A (fig. 5.8).	BC	120'	33'	175	8'	NA	585 LT	Can be towed overseas. Good hull design for relatively high-speed towing.
Deck or liquid cargo, nonpropelled, steel, 578 tons or 4,160 bbl, 120', design 231-B (fig. 5.9).	BG	120'	33'	175	8' 8"	NA	585 LT 174,720 gal.	Can be towed overseas at full load, provided maximum draft does not exceed 8'.
Repair shop, floating, marine equipment, nonpropelled, steel, 210', design 7011.	FMS	210' 5"	40'	1,160	8'	22	NA	Repair shops include electrical, carpentry, engine repair, battery, fuel injector, blacksmith, and machine. Can be towed overseas.
Deck cargo, nonpropelled, steel, 81', design 7001, sectionalized, nesting (fig. 5.10).	BK	81'	22'	57.5	5'	NA	105 LT	Can be assembled in sheltered water with few handtools and unskilled labor, but requires lift of 9- to 13.5-LT capability to place pontoons and tilt for bottom connections. Two sections can be shipped nested on larger vessels. Conversion kit 7007 makes into liquid-carrying barge. Can carry two 35-ton tanks on deck. Lacks stability.
Pier, self-elevating, nonpropelled, steel: 250', design 7024	BPL	250'	60'	1,482.4	4' 5"	NA	NA	Used to construct piers and sea island terminals. Fitted with 1 compressor for air jacks, 12 ea 100' caissons.
427', design 7025	BPL	427'	90'	4,618.3	5'	NA	NA	Same use as 7024. Fitted with 3 compressors for air jacks, 38 ea 100' caissons.

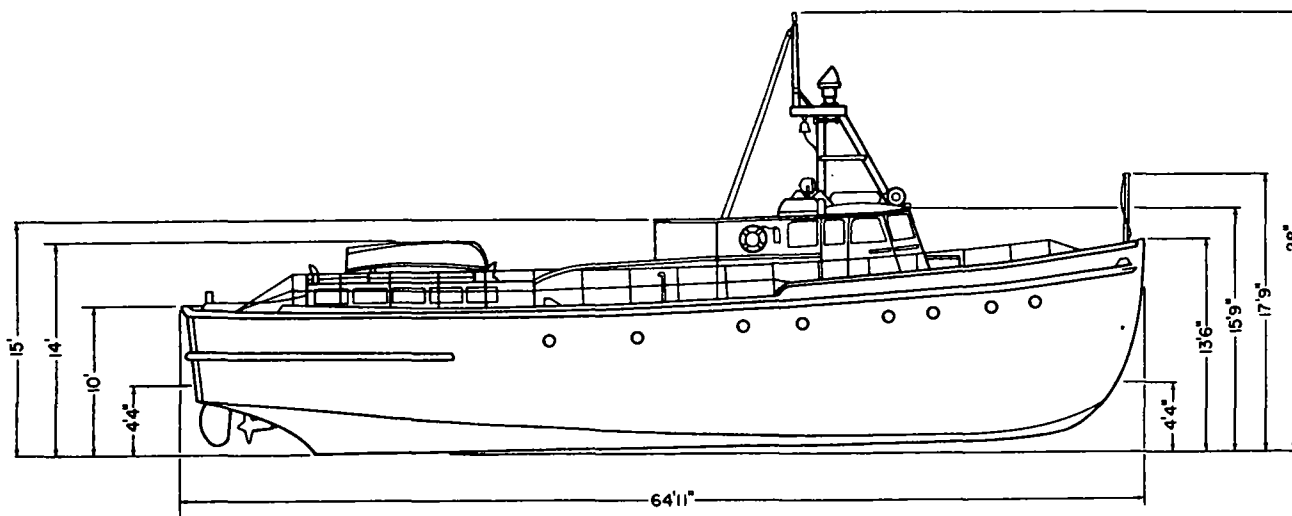


Figure 5.3. Boat, picket, diesel, wood, 64 feet 11 inches, design 4002.

5.9 Landing Ships

Type	Length	Beam	Light displacement (LT)	Draft loaded		Speed, loaded (knots)	Operating range (nautical miles)	Capacity		Cargo space
				Fwd	Aft			Cargo (LT)	Troops	
Landing ship, dock (LSD) (1 through 27).	458'	72'	4,428	18', dry; 27', flooded	18', dry; 27', flooded	15	13,000	1,233, combat	266	338' × 44' plus 56' × 24'
Landing ship, dock (LSD) (28)-----	510'	84'	6,143	19', dry; 30', flooded	19', dry; 30', flooded	15+	13,000	2,410, combat	341	396' × 50'
Landing ship, tank (LST) (1171 class).	442'	62' 1"	4,150	5' 8"	13' 11"	14	6,048	500, landing condition	634	Tank deck 10,700 sq ft Main deck 7,613 sq ft
LST (1156 class)-----	384'	55' 7"	2,309	4' 2"	9' 11"	12	6,000	446, landing condition	395	Tank deck 274' 9" × 32' 1"
LST (1153 class)-----	382'	55'	2,009	3' 4"	11' 3"	10.4	7,706	446, landing condition	197	Main deck 187' × 47' 8"
LST (542 class)-----	328'	50'	1,589	4' 4"	9' 3"	8.5	19,200	446, landing condition	141	Tank deck 280' × 30' 5"
Lighter, beach discharge ^a (fig. 5.11).	338'	65'	1,549	4', landing; 7' 8", ocean	10', landing; 13' 8", ocean	11	4,800	2,300	200	Main deck 160' × 46' Tank deck 222' 6" × 24' Main deck 100' × 45' 15,000 sq ft

^a Figures are for prototype design.

^b Designed primarily to be a vehicle carrier.

^c Vehicle drivers (without berths).

5.10 Landing Craft

Type	Length	Beam	Light displacement (LT)	Draft loaded		Speed, loaded (knots)	Operating range, nautical miles (loaded)	Fuel consumption (gal. per hour)	Crew ¹	Capacity		Cargo space dimensions
				Fwd	Aft					Cargo (LT)	Troops	
Landing craft, utility (LCU) (501 class)---	119'	32'	150	3' 4"	4'	6.5	700	34	12	133.0	300 (min)	47' 6" × 14' plus 36' × 26' plus 18' 2¼" × 12' 6".
Landing craft, utility (LCU) (1466 class) (fig. 5.12).	115'	34'	180	3'	4'	6.5	700	34	12	160.0	300 (min)	52' × 29' 6" plus 22' 5" × 14' 4".
Landing craft, mechanized, Mark VI (LCM(6)) (fig. 5.13).	56'	14'	28	3'	4' 8"	8.0	128	28	4	32.0	120	37' 6" × 9' 6"
Landing craft, mechanized, Mark VIII (LCM(8)) (fig. 5.14).	73' 8"	21'	60	3'	5' 6"	10.2	284	41	6	53.5	200	42' × 14' 6"
Landing craft, vehicle, personnel (LCVP)---	36'	10' 5"	8	2' 2"	3'	10.5	135	15	4	3.5	36	17' 3" × 7' 5"

¹ For around-the-clock operations.

5.11 Amphibious Vehicles

Type	Length	Beam	Light displacement (LT)	Draft loaded		Speed, loaded	Operating range, loaded (miles)	Fuel consumption (gal. per hour)	Crew ¹	Capacity		Cargo space dimensions
				Fwd	Aft					Cargo (LT)	Troops	
Landing vehicle, wheeled (DUKW) ² .	31'	8' 2 1/8"	6.4	3' 6"	4' 3"	5 knots, water 50 mph, land	30, water 250, land	8	3	Normal 2.2 Maximum 4.5	25	12' 5" × 6' 10"
Lighter, amphibious, 5-ton (LARC-5) ² (fig. 5.15).	35'	10'	7.2	4' 1"	4' 3"	8.7 knots, water 25 mph, land	60, water 160, land	20	2	Normal 4.5 Maximum 5.0	Emergency 20	16' × 8' 8"
Lighter, amphibious, 60-ton ² (BARC) (fig. 5.16).	62' 6 3/4"	26' 7"	87	8' 8"	8' 8"	7 knots, water 14 mph, land	105, water 210, land	40	8	Normal 53.6 Emergency 89.3	Normal 125 Emergency 200	38' 3" × 14'
Landing vehicle, tracked, Mark V (LVTP) ² .	29' 8"	11' 8 1/2"	31.2	5' 3"	5' 3"	6.7 knots, water 27.8 mph, land	45, water 187, land	47	3	Water 6.0 Land 9.0	34	15' 2" × 7' 9" × 5' 3"

¹ For around-the-clock operations.

² Transportability (see 5.9, 5.16, 5.17 and 7.4)

DUKW may be deck or hold loaded on any general cargo vessel.

LARC-5 may be deck-loaded on general cargo vessel or in well of LSD.

BARC and LVTP may be deck- or hold-loaded on special heavy-lift ship or in well of LSD.

5.12 Navy Transport Vessels

Type	Number of ships in class	Class	Type	Length	Loaded draft	Troop capacity	Cargo capacity (LT)	Cargo space	Boat capacity	Cruising range (nautical miles)
Amphibious force flagship (AGC)-----	16		C-2	459'	24'	*600	-----	-----	8 LCVP's	30,000
Attack transport (APA)-----	57	Haskell	-----	455'	24'	1,565	446	13,000 sq ft 110,000 cu ft	2 LCM(6)'s 22 LCVP's	9,800
Attack transport (APA)-----	6	Bayfield	-----	492'	27'	1,647	446	15,000 sq ft 160,000 cu ft	4 LCM(6)'s 23 LCVP's	11,630
Attack cargo ship (AKA)-----	35	Montague	C-2A	459'	24'	212	1,335 to 1,600	31,858 sq ft 291,706 cu ft	8 LCM(6)'s 16 LCVP's	12,000
High speed transport (APD)-----	21	-----	EX-DDE	306'	13'	162	45	3,730 cu ft	4 LCVP's	5,100
Transport submarine (ASSP)-----	2	Sea Lion	-----	312'	-----	85	26.7	-----	20 rubber landing boats	-----
Roll-on, roll-off, vehicle ship (T-AK) ^b -----	1	Comet	C-4	499'	22'	-----	4,000 (375 vehicles)	*60,000 sq ft d176,500 cu ft	-----	13,000

* Includes Navy staff.

^b MSTs vessel.

• Vehicle parking space.

^d In addition to vehicle parking space.

5.13 Maritime Administration Vessel Classification System

a. *Method.* The classification system established by the United States Maritime Administration is based upon three groups of letters and numbers. The first group (prefix) indicates the type of vessel, such as cargo or passenger, and its approximate

size. The second group (intermediate) indicates the type of machinery, number of screws, and passenger accommodation. The third group (suffix) indicates the particular design of the type of vessel and modifications. For example: C2-S-AJ1 describes a cargo ship between 400 and 450 feet long (C2); single screw, steam machinery (S), and the AJ design (AJ), in its original version (1).

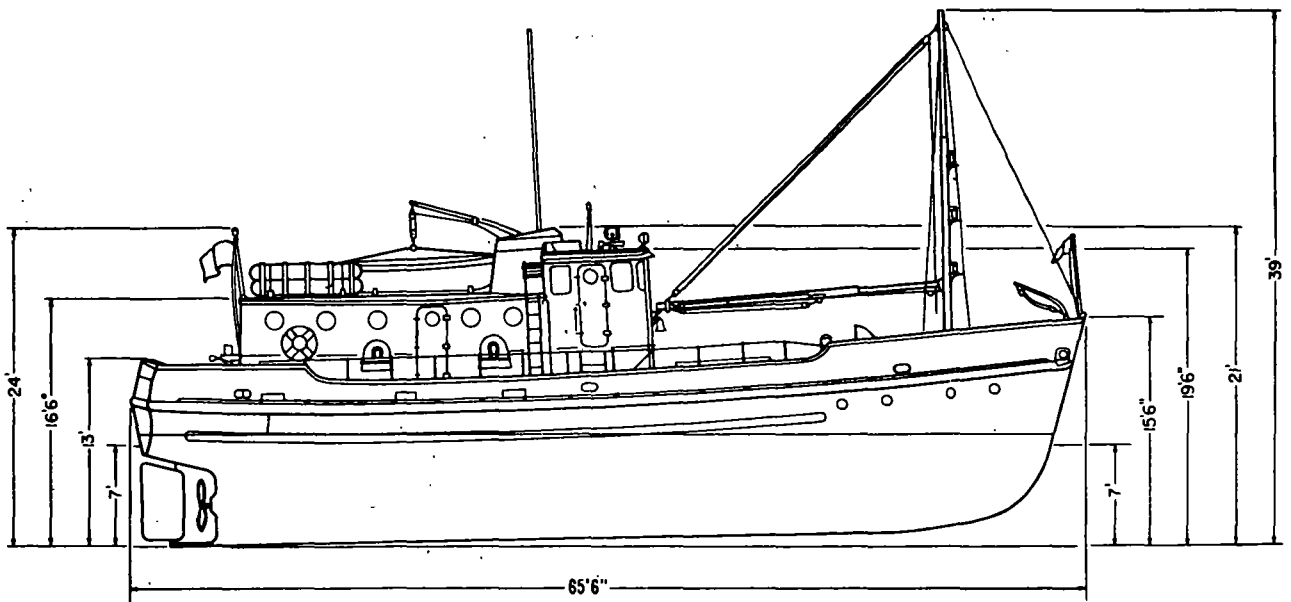
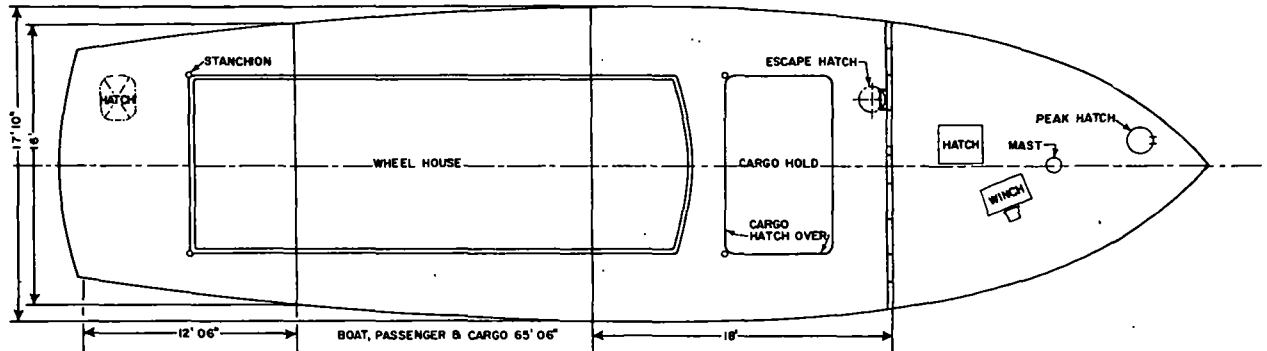


Figure 5.4. Boat, passenger and cargo, diesel, steel, 65 feet 6 inches, design 2001.

b. Prefix Designations.

(1) Other than emergency and Victory types.

Single letter	Class of vessel	Length designation (load waterline in feet)						
		1	2	3	4	5	6	7
C	Cargo, unlimited service, under 100 passengers.	Under 400	400-450	450-500	500-550			
P	Passenger, unlimited service, over 100 passengers.	Under 500	500-600	600-700	700-800	800-900	900-1,000	Over 1,000
B	Barge.....	Under 100	100-150	150-200	200-250	250-300		
L	Great Lakes tankers (ore, grain).....	Under 400	400-450	450-500	500-550	550-600	600-650	
N	Coastwise cargo.....	Under 200	200-250	250-300	300-350	350-400	400-450	450-500
R	Refrigerator.....	Under 400	400-450	450-500	500-550			
S	Special.....	Under 200	200-300	300-400	400-500	500-600	600-700	
T	Tanker.....	Under 450	450-500	500-550				
V	Towing vessels.....	Under 50	50-100	100-150	150-200			
Z	Conversion*							

* For conversions of established types, "Z" is prefixed to original designation with new final number in some cases.

(2) Emergency and Victory types.

Double letter	Class of vessel	Length designation (load waterline in feet)			
		1	2	3	4
EC	Emergency cargo (Liberty ship).....	Under 400	400-450	450-500	500-550
ET	Emergency tanker.....	450			
VC	Victory cargo.....	Under 400	400-450	450-500	500-550

(3) Older designs. The following older designs have prefixes similar to those in (1) above, but do not follow the same system for the intermediate and suffix portions. The letters or words after the hyphen are simply distinguishing characters.

C1-A	C2-Seas shipping	C3-E
C1-B	C2-SU	C3-IN (P&C)
C2-Diesel	C2-SU Reefers	C3-M
C2-F	C2-T	C3 (P&C) Diesel
C2-G	C2-Turbine	C3 (P&C) Turbine
C2-Modified	C3-A (P&C)	C3-P (P&C)
C2-S	C3-Diesel	C3-Turbine

c. Intermediate Letter or Group.

Type of machinery	Type of propeller	Under 12 passengers	Over 12 passengers
Steam.....	Single.....	S	S1
Motor.....	Single.....	M	M1
Turboelectric.....	Single.....	SE	SE1
Diesel-electric.....	Single.....	ME	ME1
Gas turbine.....	Single.....	G	G1
Gas turboelectric.....	Single.....	GE	GE1

Type of machinery	Type of propeller	Under 12 passengers	Over 12 passengers
Steam.....	Twin.....	ST	S2
Motor.....	Twin.....	MT	M2
Turboelectric.....	Twin.....	SET	SE2
Diesel-electric.....	Twin.....	MET	ME2
Gas turbine.....	Twin.....	GT	G2
Gas turboelectric.....	Twin.....	GET	GE2
Steam.....	Stern wheel.....	SW	SO
Motor.....	Stern wheel.....	MW	MO

d. Suffix. The third group, or suffix, identifies the particular design and indicates the approximate time the design originated. The alphabetical letters are assigned in series. Therefore, if there is only one letter, this indicates that the design originated earlier than one having two letters. The figure following the letter or letters in the suffix indicates that it is either the original design of that particular alphabetical designation or a modification thereof. The original design is always numbered 1.

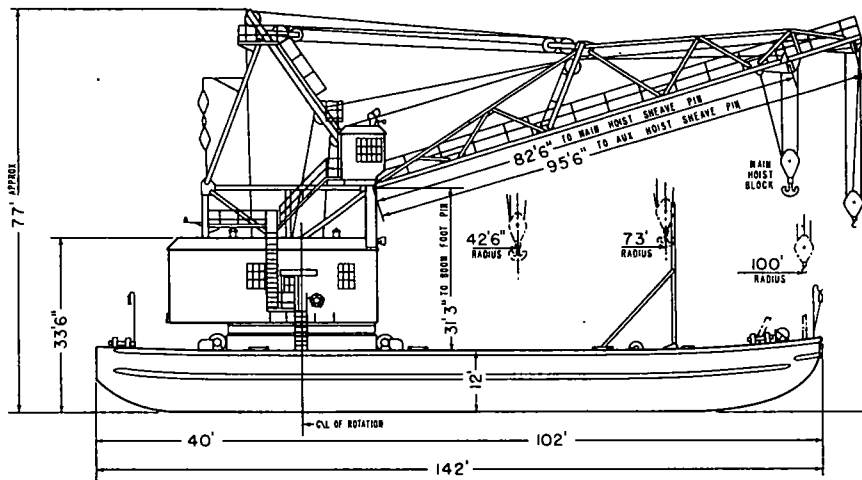


Figure 5.5. Crane, barge, diesel-electric, revolving, steel, 60 long tons, design 413D.

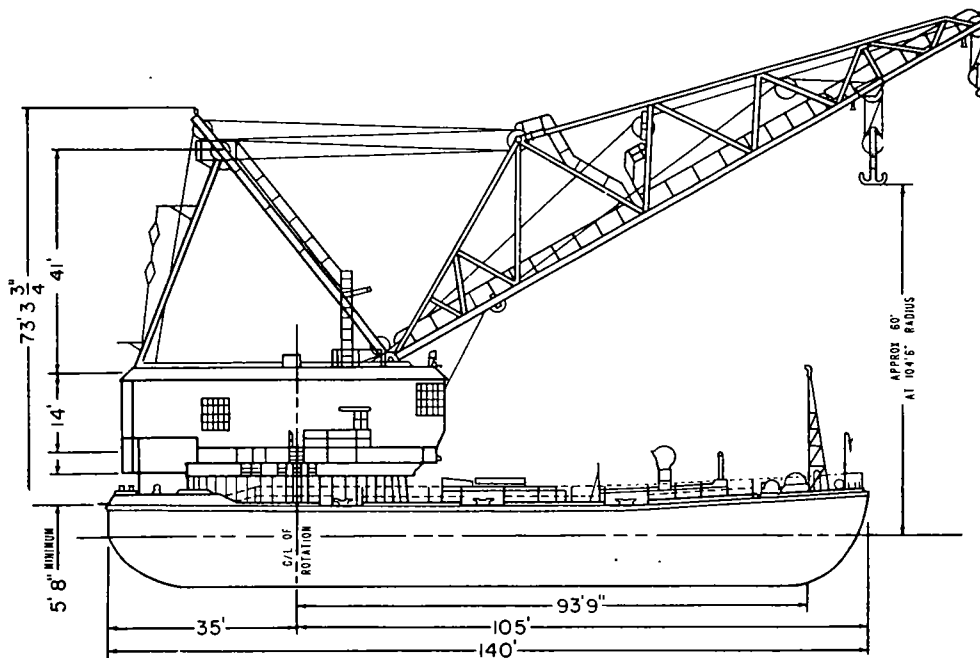


Figure 5.6. Crane, barge, diesel-electric, revolving, steel, 89 long tons, design 264B.

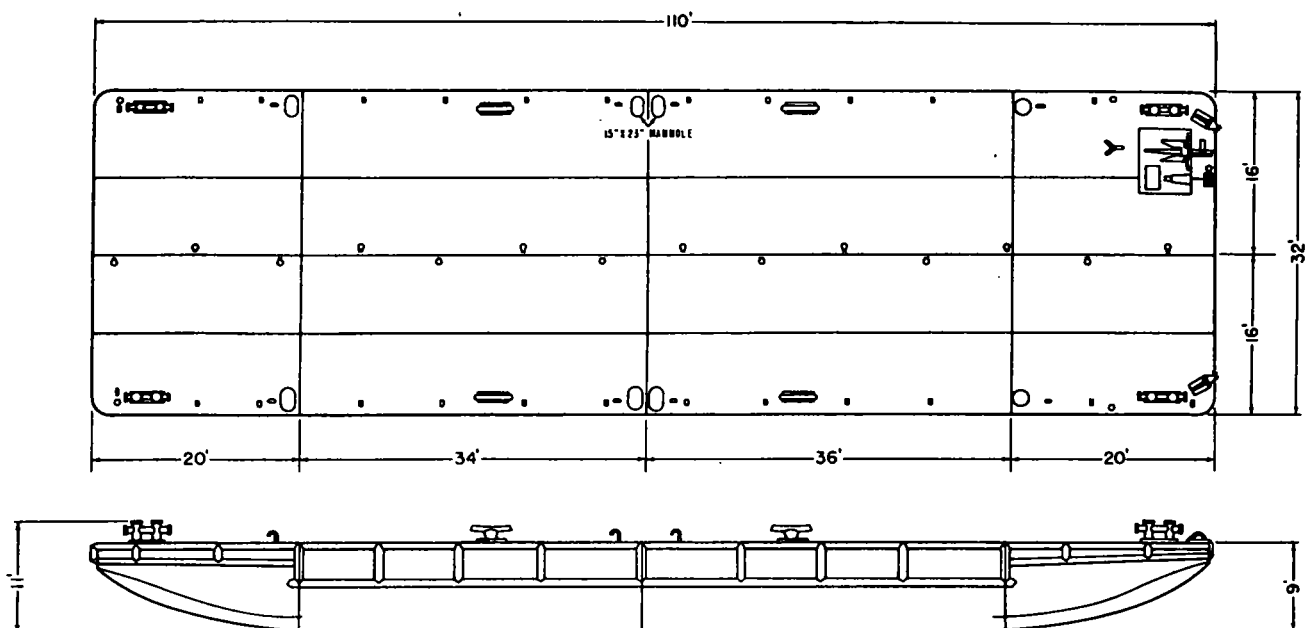


Figure 5.7. Barge, deck cargo, nonpropelled, steel, 570 tons, 110 feet, design 7005.

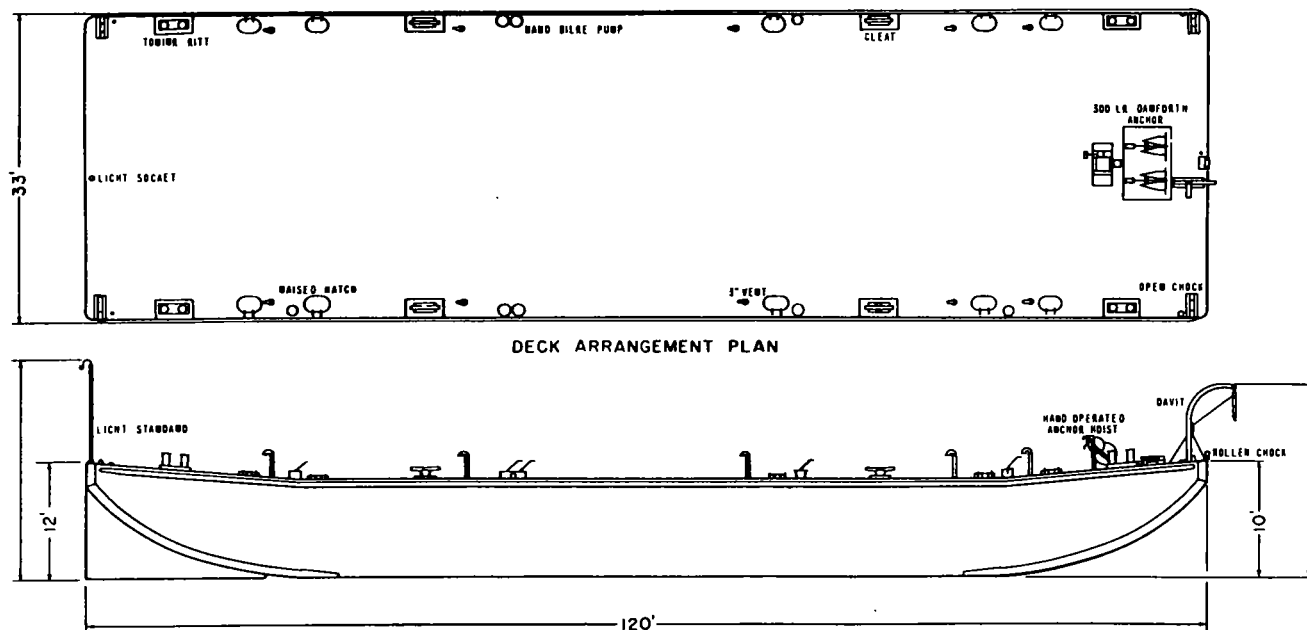


Figure 5.8. Barge, deck cargo, nonpropelled, steel, 585 tons, 120 feet, design 231A.

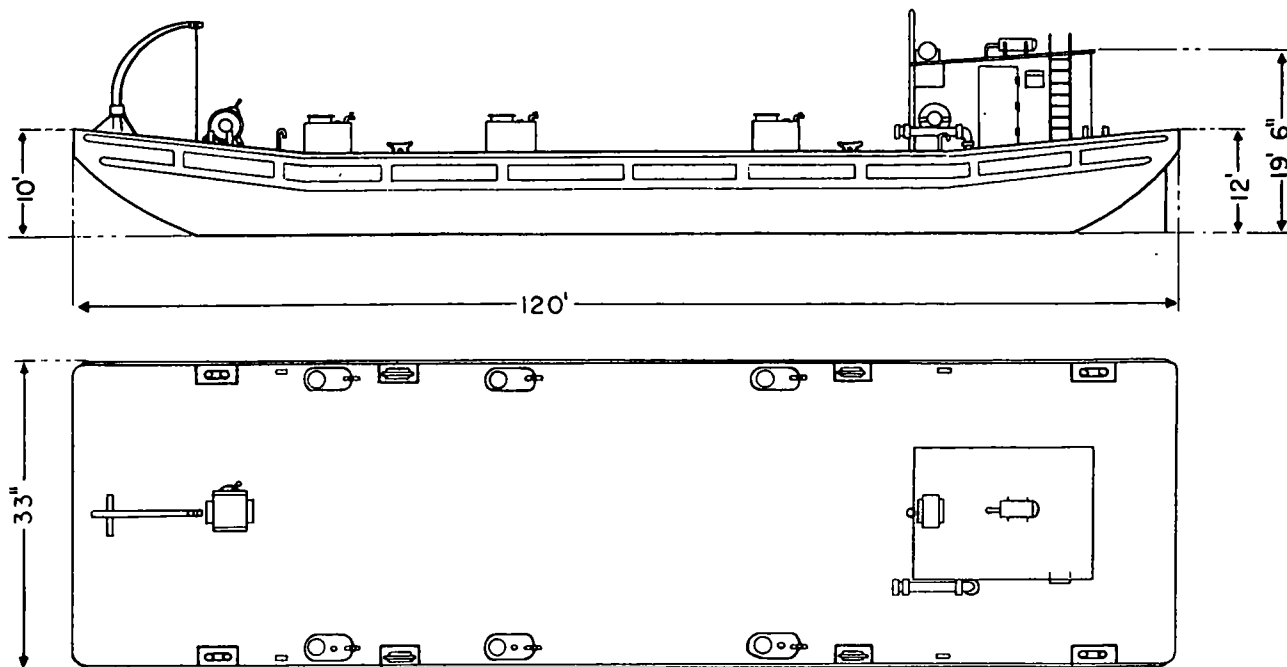


Figure 5.9. Barge, deck and liquid cargo, nonpropelled, steel, 578 tons or 4,160 barrels, 120 feet, design 231 B.

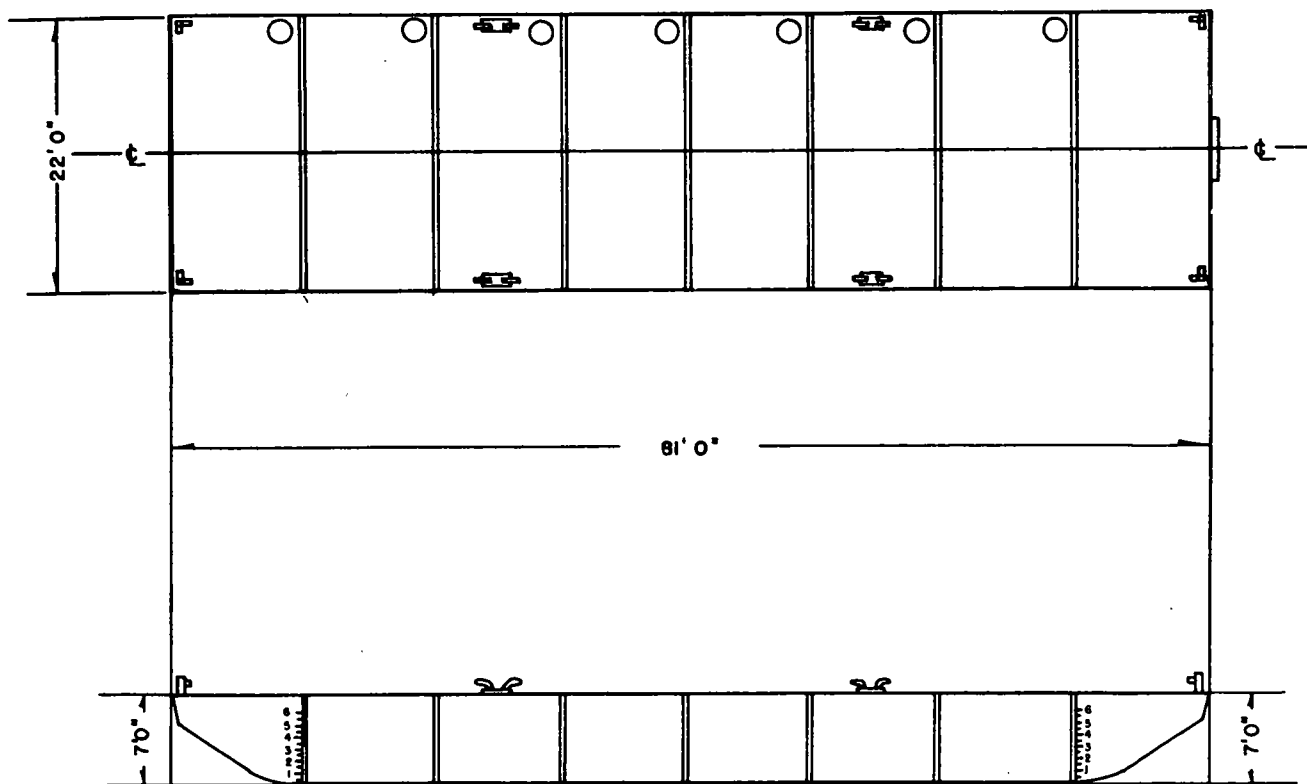


Figure 5.10. Barge, deck cargo, nonpropelled, steel, 130 tons, 81 feet, sectionalized, nesting, design 7001.



5.14 Commercial Vessels

Type	Description	Type	Description
B7	Concrete hull, cargo barge, nonpropelled.	EC2	Liberty type designed for general cargo; steam reciprocating engine propelled. Several modified types, prefixed by the symbol "Z," were designed as tank carriers and later modified as plane carriers.
C1-A	Designed for general cargo in world trade; steam-turbine and motor-propelled (four modifications).	L6	Specially designed for coal or grain trade on the Great Lakes; steam reciprocating engine propelled.
C1-B	Designed for general cargo in world trade; steam-turbine and motor-propelled (four modifications).	N3	Cargo carrier designed for coastal trade; steam reciprocating engine propelled.
C1-M	Designed for general cargo; motor-propelled.	P1	Specially designed passenger-type vessel; steam-turbine propelled.
C1-S	Concrete barge designed for cargo purposes; steam reciprocating engine propelled.	P2	Designed to carry troops. Two types: turbine-electric propelled, steam-turbine propelled.
C2	Designed for general cargo in world trade; steam-turbine propelled (several modified types). Those prefixed by the symbol "Z" were in operation during World War II. Modified types were used mostly as hospital ships.	T1	Designed for tanker service in coastal and inland waters; diesel propelled (five modifications).
C3	Combination passenger and cargo ship; steam-turbine propelled (several modified types).	T2	Designed to carry bulk oil in world trade; turbo-electric propelled (two modifications).
C3-S	Designed for cargo; steam-turbine propelled.	T3	Designed to carry bulk oil in world trade; steam-turbine propelled (three modifications).
C4	Designed for cargo; steam-turbine propelled (two modifications).	V4	Large diesel-powered oceangoing tug.
C4-S-1a	Mariner class. Recently developed by Maritime Administration in cooperation with the Department of Defense to provide modern high-	VC2	Victory type designed to carry cargo in world trade. Three types, one with 6,000-hp engine, two with 8,500-hp engines. All three are steam-turbine propelled.

5.15 Commercial Cargo Ships

Type	Length	Beam	Loaded draft	Dead-weight tonnage (LT)	Gross tonnage	Capacity (cubic feet)			Liquid cargo capacity	No. of hatches	Speed (knots)	Cruising range (nautical miles)
						Bale	Grain	Reefer				
C1-B	417' 9"	60'	28' 8 7/8"	8,777	6,711	451,624	505,877			5	14	24,440
C1-M-AV1	338' 8"	50'	21' 1"	5,087	3,805	227,730	249,835	9,830		4	11	25,130
C2-S-AJ	459' 1"	63'	27' 7 7/8"	10,828	8,258	542,824	582,845			5	15	16,200
EC2 (Liberty)	441' 6"	56' 10 3/4"	27' 8 7/8"	10,865	7,191	499,573	562,608			5	11	17,000
VC2 (Victory)	455' 3"	62'	28' 6"	10,805	7,612	456,525	528,325			5	15	23,000
C3-S-A2	492'	69' 6"	28' 6"	12,258	7,886	736,850	813,020			5	16.5	11,950
C4-S-A4	522' 10 1/2"	71' 6"	32' 9 7/8"	14,941	10,685	672,243	808,154			7	17	15,870
C4-S-B5	520'	71' 6"	32' 9 7/8"	15,014	10,780	711,580	829,310			7	18	18,380
C4-S-1a (Mariner)	563' 7 3/4"	76'	29' 10"	13,420	9,216	736,723	837,305	30,254		7	20	21,660
T2-SE-A2	523' 6"	68'	29' 11 1/2"	16,590	10,461				140,721 bbl		16.5	18,165

5.16 Hold, Hatch, and Baam Data

Vessel	No. of cargo holds	No. of booms	Boom capacity (LT)	Hatches w/hv lift booms	Hv-lift capacity (LT)
C1-B	5	15	5	2	30
C1-M-AV1	4	14	1 1/2, 5	2, 3	30
C2-S-AJ	5	17	5	3	50
EC2 (Liberty)	5	12	5	2, 4	*50-15
VC2 (Victory)	5	16	5	3, 4	50, 30
C3-S-A2	5	21	5, 10	5	30
C4-S-A4	7	25	5	6	50
C4-S-B5	7	24	5	4, 5	50
C4-S-1a (Mariner)	7	26	5, 10	4, 6	60
FS Freighter ^b	2	5	5	2	15

* Liberty ships have either a 30- or 50-ton boom at No. 2 hatch and a 15- or 30-ton boom at No. 4 hatch.

^b The FS is the 176-foot supply vessel built for the Army. It is an oceangoing vessel, but, because of its small capacity, is used principally as an interisland carrier.

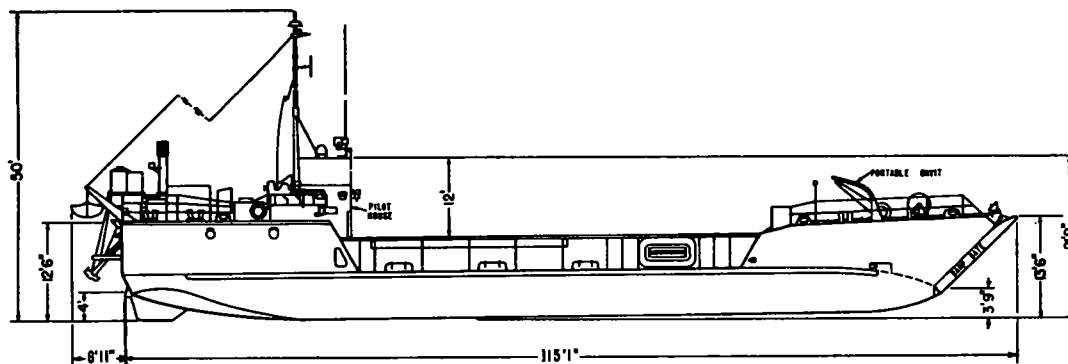
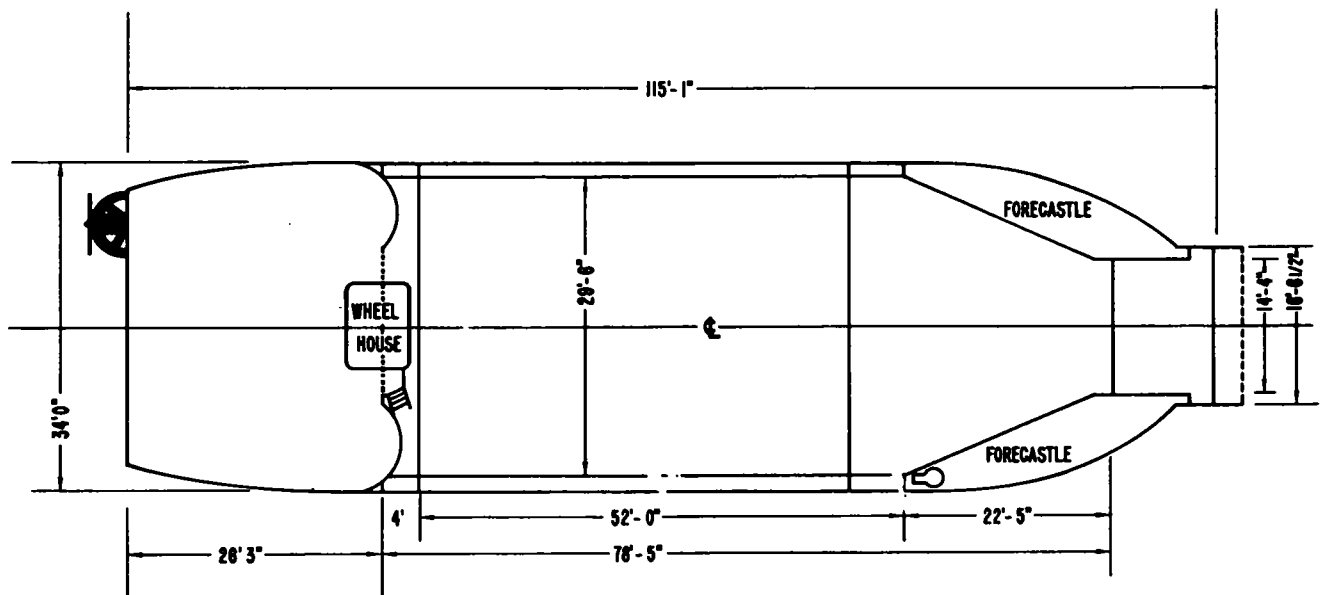


Figure 5.12. Landing craft, utility, diesel, steel, 115 feet, Navy design, LCU 1466 class.

5.17 Below-Deck Capacities

Vessel	Hatch No.	Hatch dimensions	Cargo capacities (MT)			
			Upper 'tween	Lower 'tween	Hold	Deep tanks
C1-B.....	1	29' 3" × 20'	481	398	862	480
	2	31' 6" × 20'	750	742	1,438	
	3	31' 6" × 20'	845	779	1,222	
	4	31' 6" × 20'	*102	1,229		
	5	31' 6" × 20'	780	608		
Total.....			3,532	3,756	3,522	480
C1-M-AV1.....	1	20' 1 1/2" × 19' 11"		601	616	
	2	40' 5" × 19' 11"		982	1,378	
	3	40' 5" × 19' 11"		901	1,179	
	4	9' × 8'		*169	113	
Total.....				2,653	3,286	

See footnotes at end of table.

Vessel	Hatch No.	Hatch dimensions	Cargo capacities (MT)			
			Upper 'tween	Lower 'tween	Hold	Deep tanks
C2-S-AJ.....	1	26' 10" × 19' 10"	602	519	947	
	2	32' 4" × 19' 10"	804	805	1,405	
	3	34' 10" × 19' 10"	908	968	1,514	
	4	29' 10" × 19' 10"	902	932	1,483	
	5	29' 10" × 19' 10"	722		1,056	
Total.....			3,938	3,224	6,405	
EC2 (Liberty).....	1	33' 7" × 19' 10"		983	902	416
	2	34' 10" × 19' 10"		1,065	2,300	
	3	19' 10" × 19' 10"		597	1,495	613
	4	34' 10" × 19' 10"		742	1,315	
	5	34' 10" × 19' 10"		771	1,290	
Total.....				4,158	7,302	1,029
VC2 (Victory).....	1	24' 11" × 22' 3"	551	595	698	
	2	23' 11" × 22' 3"	675	545	698	
	3	35' 11" × 22' 3"	1,139	945	1,321	
	4	35' 11" × 22' 3"	1,230		1,277	
	5	23' 11" × 22' 3"	1,091		648	
Total.....			4,686	2,085	4,642	
C3-S-A2.....	1	35' 9½" × 19' 9½"	812	1,130	1,079	
	2	29' 9½" × 23' 9½"	830	1,381	1,396	
	3	37' 3½" × 23' 9½"	1,244	1,553	2,002	
	4	29' 9½" × 23' 9½"	1,164	1,255	1,419	
	5	39' 9½" × 23' 9½"	1,009	1,704	212	
Total.....			5,059	7,023	6,108	
C4-S-A4.....	1	17' 9" × 16' 8"	496	340	141	
	2	26' 10" × 17' 9"	1,139	1,258	772	
	3	26' 10" × 17' 9"	798	651		1,084
	4	26' 10" × 17' 9"	803	1,533	994	
	5	26' 10" × 17' 9"	765	1,515	1,017	
	6	26' 10" × 17' 9"	795	782	1,636	
	7	17' 9" × 17' 1"	583	454		
Total.....			5,379	6,533	4,560	1,084
C4-S-B5.....	1	20' 0" × 18' 0"	608	293		
	2	27' 6" × 20' 0"	1,160	1,128	704	
	3	27' 6" × 20' 0"	702	641	603	837
	4	30' 0" × 20' 0"	1,626	764	1,047	
	5	30' 0" × 20' 0"	1,623	772	1,055	
	6	30' 0" × 20' 0"	1,540	794	998	
	7	20' 3" × 18' 0"	95	482	358	
Total.....			7,354	4,874	4,765	837
C4-S-1a (Mariner).....	1	19' 6" × 17' 9"	402	453	305	
	2	29' 10" × 23' 10"	731	865	637	
	3	39' 10" × 29' 10"	1,050	1,454	1,284	
	4	39' 10" × 29' 10"	1,006	1,500	1,528	
	5	39' 10" × 29' 10"	1,044	410	401	953

See footnotes at end of table.

Vessel	Hatch No.	Hatch dimensions	Cargo capacities (MT)			
			Upper 'tween	Lower 'tween	Hold	Deep tanks
Total.....	6	39' 10" × 29' 10"	965		1,646	298
	7	29' 10" × 24' 10"	1,627		856	
			6,825	4,682	6,657	1,251
FS Freighter.....	1	20' 0" × 16' 0"			251	
	2	28' 0" × 16' 0"			285	
					536	

- Special cargo locker on upper 'tween level between hatches Nos. 3 and 4.
- Includes 36 MT in trunked hatch.
- Includes upper deck and second deck.
- Includes third deck and first platform.
- Liquid cargo space.
- Includes refrigerated cargo space.
- Includes main 'tween deck.

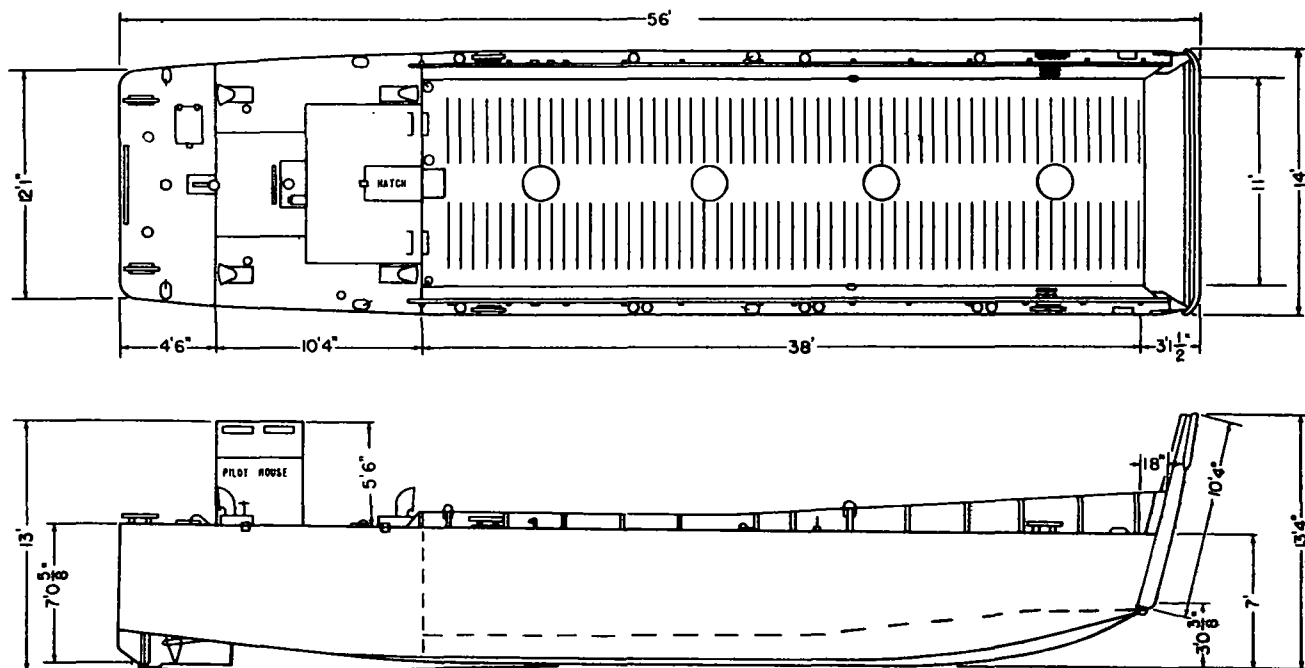


Figure 5.13. Landing craft, mechanized, diesel, 56 feet, Mark VI, Navy design, LCM(6).

5.18 Vehicle-Loading Capacities

These figures reflect general loading conditions and by no means represent the maximum vehicle capacities of the vessels. With the exception of

crated vehicles, no allowance has been made for stacking or double decking. All below-deck stowage is fore and aft except in the case of $\frac{1}{4}$ -ton trucks and $1\frac{1}{2}$ -ton trailers, which are stowed both fore and aft and athwartship.

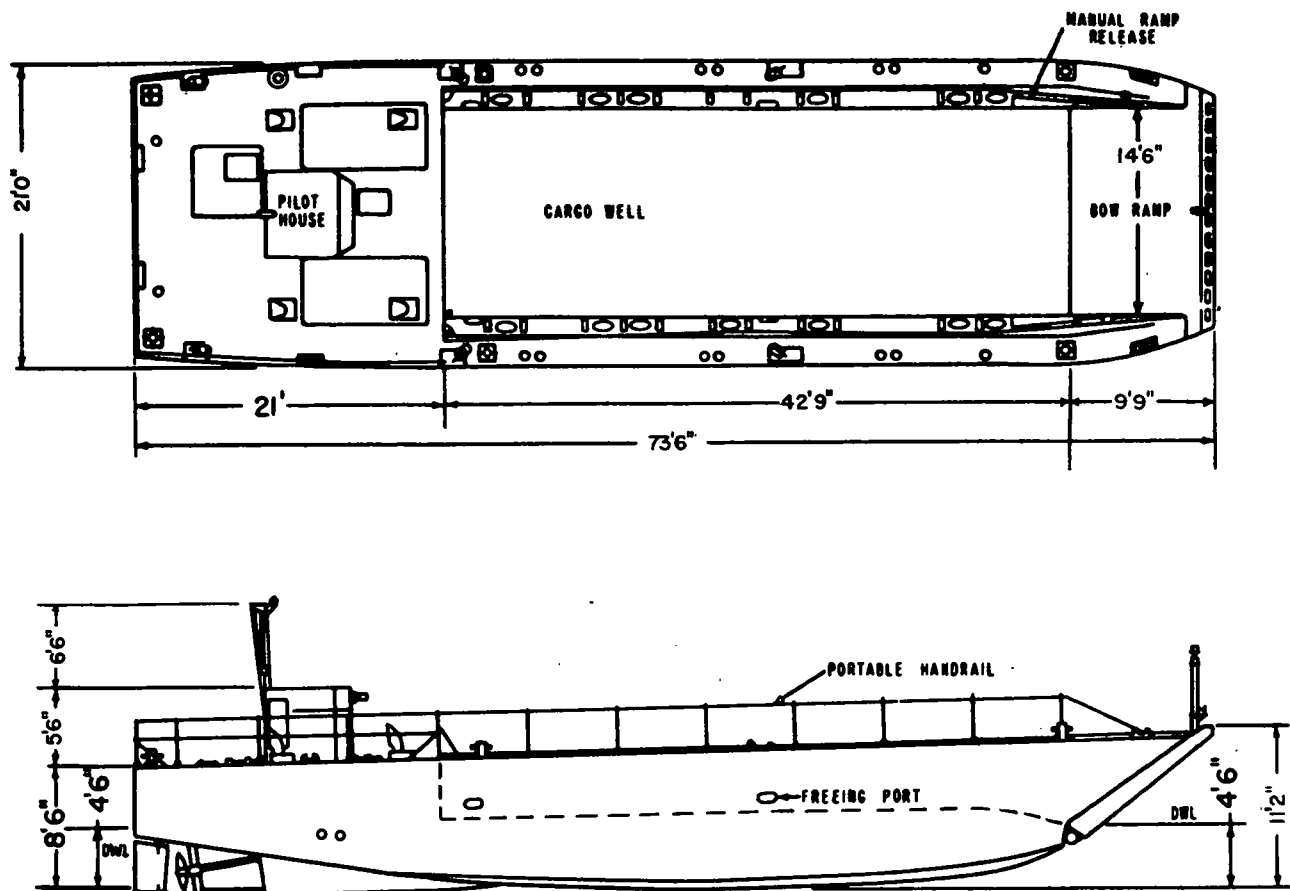


Figure 5.14. Landing craft, mechanized, diesel, steel, 69 feet, Mark VIII, Navy design, LCM(8).

a. C4-S-1a (Mariner).

Hatch No.	Location	Trailer, cargo, 1 1/2-ton	Truck, utility, 1/2-ton	Truck, cargo		
				1/4 T 4 x 4	2 1/2 T 6 x 6 LWB	5 T 6 x 6 LWB
1	On deck.....	20	20	11	7	4
	'Tween deck:					
	Upper.....	16	20	12	6	4
	Lower.....	10	14	9	4	0
2	Hold.....	5	9	6	3	0
	On deck.....	23	33	20	10	7
	'Tween deck:					
	Upper.....	23	37	22	11	7
3	Lower.....	21	26	15	9	7
	Hold.....	11	15	9	5	2
	On deck.....	42	52	30	20	10
	'Tween deck:					
4	Upper.....	48	61	38	25	13
	Lower.....	44	52	32	21	13
	Hold.....	32	36	22	14	9
	On deck.....	36	52	26	18	10
	'Tween deck:					
	Upper.....	46	69	38	20	14
	Lower.....	46	69	38	20	14
	Hold.....	44	56	30	16	12

Hatch No.	Location	Trailer, cargo, 1 1/2-ton	Truck, utility, 1/4-ton	Truck, cargo		
				3/4 T 4 x 4	2 1/2 T 6 x 6 LWB	5 T 6 x 6 LWB
5	On deck	36	54	28	20	12
	'Tween deck:					
	Upper	56	72	42	18	14
	Lower	58	74	44	18	14
	Hold	56	72	42	16	12
6	Deep tank	28	36	14	6	2
	On deck	40	54	30	20	12
	'Tween deck	47	65	36	18	14
	Hold	30	34	20	12	9
	Deep tank	4	10	0	0	0
7	On deck	27	37	22	12	7
	'Tween deck	33	42	23	11	7
	Hold	9	10	6	4	0

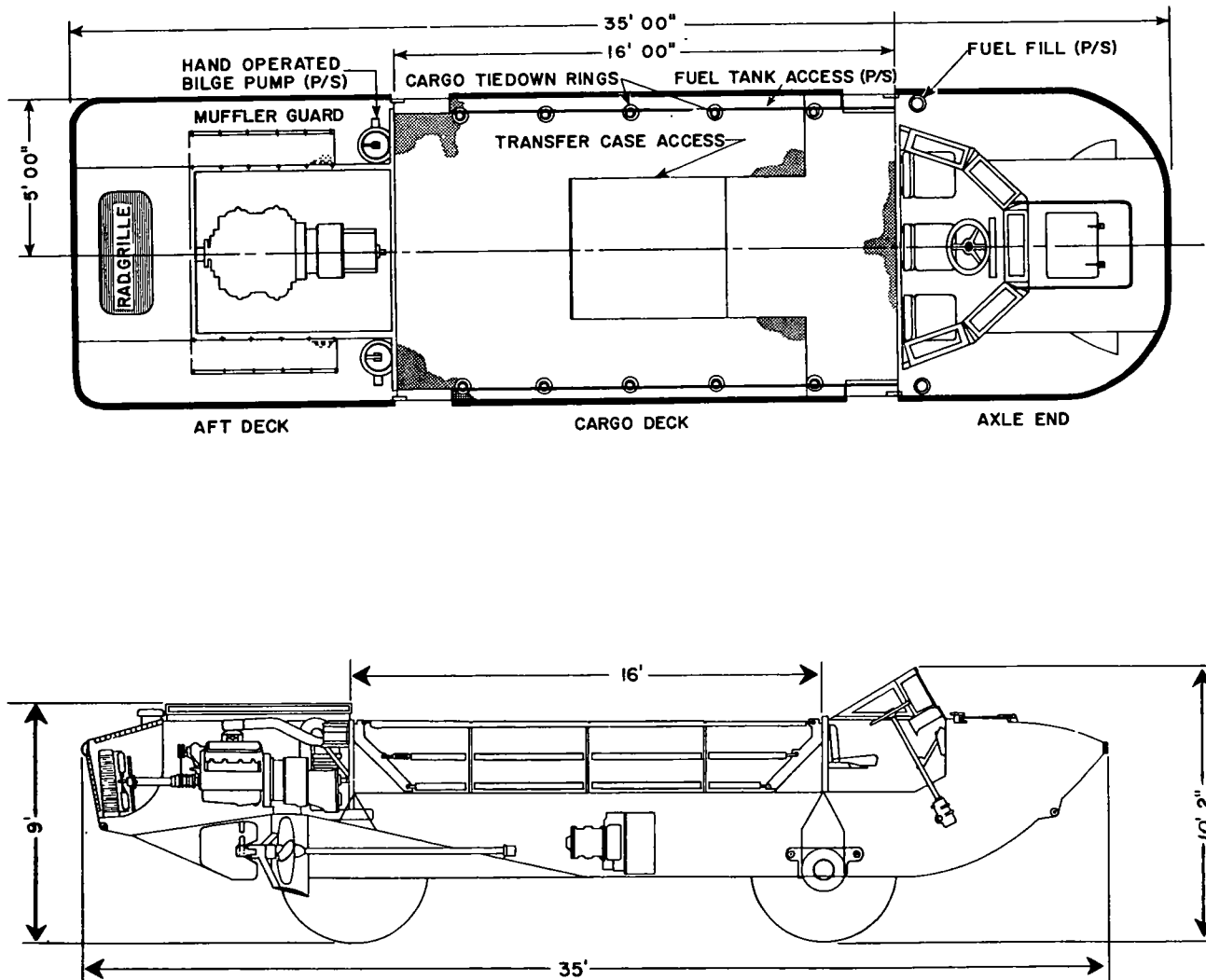


Figure 5.15. Lighter, amphibious (LARC), 5 tons, design 8005.

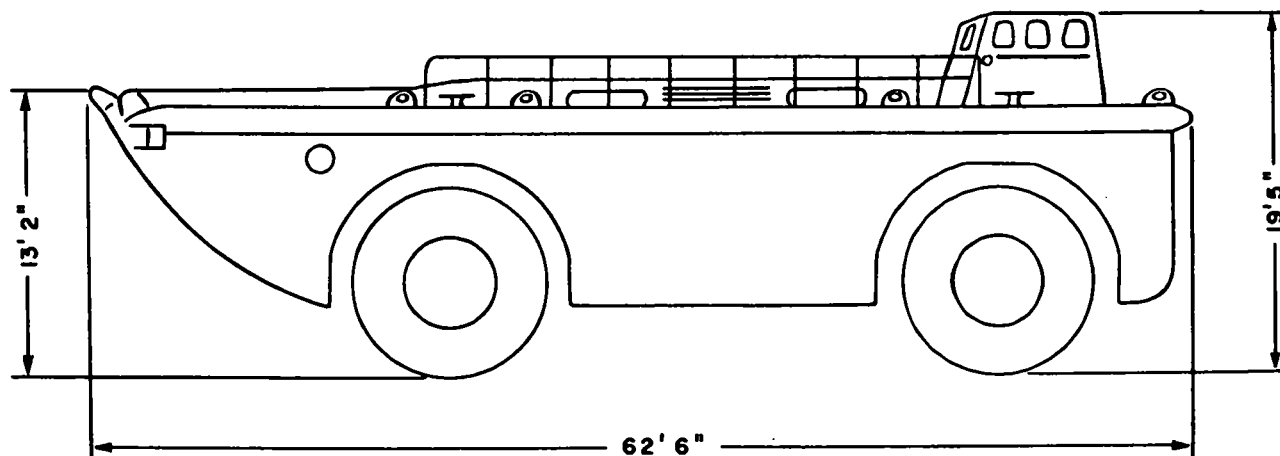
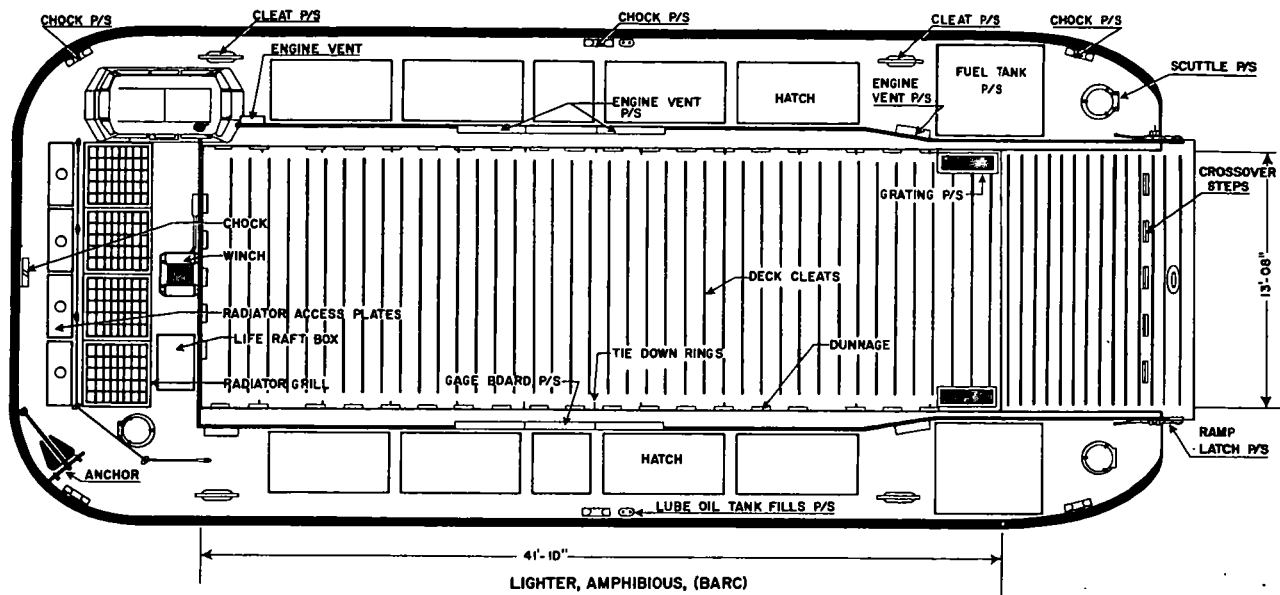


Figure 5.16. Lighter, amphibious (BARC), self-propelled, diesel, steel, 60-tons, 61 feet, design 2303.

b. C1-B.

Hatch No.	Location	Trailer cargo, 1½-ton	Truck, utility, ¼-ton	Truck, cargo		
				¾ T 4 × 4	2½ T 6 × 6 LWB	5 T 6 × 6 LWB
1	On deck.....	14	14	12	5	7
	'Tween deck:					
	Upper.....	18	21	12	6	4
	Lower.....	18	21	12	6	5
2	Lower hold.....	13	14	9	4	4
	On deck.....	21	25	18	12	7
	'Tween deck:					
	Upper.....	37	46	25	13	12
	Lower.....	37	42	25	15	12
	Lower hold*.....	36	34	21	13	11

* See footnote at end of b.

Hatch No.	Location	Trailer, cargo, 1½-ton	Truck, utility, ¼-ton	Truck, cargo		
				¾ T 4 × 4	2½ T 6 × 6 LWB	5 T 6 × 6 LWB
3	On deck	21	23	14	10	5
	'Tween deck:					
	Upper	42	44	30	17	12
	Lower	42	41	28	13	12
4	Lower hold*	42	41	28	13	9
	On deck	21	21	14	10	7
	'Tween deck:					
	Upper	41	39	26	14	12
5	Lower	37	36	24	12	10
	On deck	18	16	12	7	5
	'Tween deck	23	23	15	7	5
	Hold	10	10	12	6	6

* Number of vehicles (except 5-ton, 6 × 6) can be doubled by flooring over one layer of vehicles and loading a second layer directly on top. The depth of only these two holds will permit such double decking.

c. EC2 (Liberty).

Hatch No.	Location	Trailer, cargo, 1½-ton	Truck, utility, ¼-ton	Truck, cargo		
				¾ T 4 × 4	2½ T 6 × 6 LWB	5 T 6 × 6 LWB
1	On deck	22	22	14	9	6
	'Tween deck	27	28	23	12	8
	Lower hold	24	28	18	10	5
2	On deck	36	41	20	13	8
	'Tween deck	44	54	30	21	12
	Lower hold	42	48	*30	*18	12
3	On deck	14	22	10	6	4
	'Tween deck	28	36	25	14	6
	Lower hold	28	32	*22	12	6
4	On deck	20	31	16	11	8
	'Tween deck	37	41	27	16	8
	Lower hold	15	20	18	10	2
5	On deck	22	31	14	11	6
	'Tween deck	34	44	25	16	9
	Lower hold	11	20	20	6	2

* Based on no centerline bulkhead, which may or may not be standard equipment.

d. VC2 (Victory).

Hatch No.	Location	Trailer, cargo, 1½-ton	Truck, utility, ¼-ton	Truck, cargo		
				¾ T 4 × 4	2½ T 6 × 6 LWB	5 T 6 × 6 LWB
1	On deck	12	14	6	5	4
	'Tween deck:					
	Upper	16	15	9	5	0
	Lower	18	16	9	6	3
	Hold	13	15	8	4	3
2	On deck	16	18	12	7	4
	'Tween deck:					
	Upper	26	29	17	10	4
	Lower	24	25	17	10	5
	Hold	21	21	14	8	3
3	On deck	29	25	18	13	8
	'Tween deck:					

Hatch No.	Location	Trailer, cargo, 1 1/2-ton	Truck, utility, 3/4-ton	Truck, cargo		
				3/4 T 4 = 4	2 1/2 T 6 = 6 LWB	5 T 6 = 6 LWB
4	Upper.....	48	48	29	17	12
	Lower.....	46	46	30	18	12
	Hold.....	46	44	30	18	8
	On deck.....	25	23	18	13	8
	'Tween deck.....	48	49	34	16	14
5	Hold.....	49	49	31	18	13
	On deck.....	25	25	17	6	4
	'Tween deck.....	31	30	20	12	6
	Hold.....	19	20	12	7	3

e. C1-M-AV1.*

Hatch No.	Location	Trailer, cargo, 1 1/2-ton	Truck, utility, 3/4-ton	Truck, cargo		
				3/4 T 4 x 4	2 1/2 T 6 x 6 LWB	5 T 6 x 6 LWB
1	On deck.....	14	20	13	7	4
	'Tween deck.....	23	30	16	10	3
	Hold.....	13	16	7	4	2
2	On deck.....	24	30	18	10	8
	'Tween deck.....	46	51	28	19	10
	Hold.....	45	51	28	19	10
3	On deck.....	22	28	14	10	6
	'Tween deck.....	37	44	27	17	9
	Hold.....	37	44	26	15	9

* No. 4 hatch is not large enough for vehicle loading.

5.19 United States Navy Ship and Service Craft Designators

a. Combatant Vessels.

(1) Warships.

BB.....battleship
BBG.....guided missile capital ship
CA.....heavy cruiser
CAG.....guided missile heavy cruiser
CG.....large cruiser
CBC.....large tactical command ship
CG.....guided missile cruiser
CL.....light cruiser
CLAA.....antiaircraft light cruiser
CLC.....tactical command ship
CLG.....guided missile light cruiser
CVA.....attack aircraft carrier
CVE.....escort aircraft carrier
CVHE.....escort helicopter aircraft carrier
CVL.....small aircraft carrier
CVS.....antisubmarine support aircraft carrier
DD.....destroyer
DDC.....corvette
DDE.....escort destroyer
DDG.....guided missile destroyer
DDR.....radar picket destroyer
DL.....frigate

DLG.....guided missile frigate
SS.....submarine
SSG.....guided missile submarine
SSK.....antisubmarine submarine
SSR.....radar picket submarine

(2) Amphibious warfare vessels.

AGC.....amphibious force flagship
AKA.....attack cargo ship
APA.....attack transport
APD.....high-speed transport
ASSP.....transport submarine
CVHA.....assault helicopter aircraft carrier
DEC.....control escort vessel
IFS.....inshore fire support ship
LPH.....amphibious assault ship
LSD.....dock landing ship
LSFF.....flotilla flagship landing ship
LSIL.....infantry landing ship (large)
LSM.....medium landing ship
LSMR.....medium landing ship (rocket)
LSSL.....support landing ship (large)
LST.....tank landing ship

(3) Mine warfare vessels.

DM.....minelayer, destroyer
DMS.....minesweeper, destroyer
MCS.....mine warfare command and support

MHC.....minehunter, coastal
 MMA.....minelayer, auxiliary
 MMC.....minelayer, coastal
 MMF.....minelayer, fleet
 MSC.....minesweeper, coastal
 MSC(O).....minesweeper, coastal (old)
 MSF.....minesweeper, fleet (stl hull)
 MSO.....minesweeper, ocean (nonmag)

(4) *Patrol vessels.*

DE.....escort vessel
 DER.....radar escort vessel
 PC.....submarine chaser (173')
 PCE.....escort (180')
 PCER.....rescue escort (180')
 PCS.....submarine chaser (136')
 PF.....patrol escort
 PGM.....motor gunboat
 PR.....river gunboat
 PY.....yacht
 SC.....submarine chaser (110')

b. *Auxiliary Vessels.*

AD.....destroyer tender
 ADG.....degaussing vessel
 AE.....ammunition ship
 AF.....store ship
 AG.....miscellaneous
 AGB.....icebreaker
 AGP.....motor torpedo boat tender
 AGS.....surveying ship
 AGSC.....coastal surveying ship
 AG(SS).....auxiliary submarine
 AH.....hospital ship
 AK.....cargo ship
 AKD.....cargo ship, dock
 AKL.....light cargo ship
 AKN.....net cargo ship
 AKS.....general stores issue ship
 AKV.....cargo ship and aircraft ferry
 AN.....net laying ship
 AO.....oiler
 AOG.....gasoline tanker
 AOR.....replenishment fleet tanker
 AO(SS).....submarine oiler
 AP.....transport
 APB.....self-propelled barracks ship
 APC.....small coastal transport
 AR.....repair ship
 ARB.....battle damage repair ship
 ARC.....cable repairing or laying ship
 ARG.....internal combustion engine repair ship
 ARL.....landing craft repair ship
 ARS.....salvage vessel
 ARSD.....salvage lifting vessel
 ARST.....salvage craft tender
 ARV.....aircraft repair ship
 ARVA.....aircraft repair ship (aircraft)
 ARVE.....aircraft repair ship (engine)
 AS.....submarine tender
 ASR.....submarine rescue vessel
 ATA.....auxiliary ocean tug
 ATF.....fleet ocean tug
 ATR.....rescue ocean tug

AV.....seaplane tender
 AVD.....advanced aviation base ship
 AVM.....guided missile ship
 AVP.....small seaplane tender
 AVS.....aviation supply ship
 AW.....distilling ship
 IX.....unclassified miscellaneous

c. *Service Craft.*

AFDB.....large auxiliary floating drydock
 AFDL.....small auxiliary floating drydock
 AFDM.....medium auxiliary floating drydock
 APL.....barracks ship (nonpropelled)
 ARD.....floating drydock auxiliary
 LCU.....utility landing craft
 MSA.....minesweeper auxiliary
 MSB.....minesweeping boat
 MSI.....minesweeper inshore
 PT.....motor torpedo boat
 PYC.....coastal yacht
 SST.....target and training submarine
 X.....submersible craft
 XFU.....harbor utility craft
 XMAP.....sweeper device
 YAG.....miscellaneous auxiliary
 YAGR.....ocean radar station ship
 YC.....open lighter
 YCF.....car float
 YCK.....open cargo lighter
 YCV.....aircraft transportation lighter
 YD.....floating derrick
 YDT.....diving tender
 YF.....covered lighter (self-propelled)
 YFB.....ferryboat or launch
 YFD.....yard floating drydock
 YFN.....covered lighter (nonpropelled)
 YFNB.....large covered lighter
 YFND.....covered lighter (used with drydock)
 YFNG.....covered lighter (special purpose)
 YFNX.....lighter (special purpose)
 YFP.....floating power barge
 YFR.....refrigerated covered lighter (self-propelled)
 YFRN.....refrigerated covered lighter (nonpropelled)
 YFRT.....covered lighter (range tender)
 YFT.....torpedo transportation lighter
 YFU.....harbor utility craft
 YG.....garbage lighter (self-propelled)
 YGN.....garbage lighter (nonpropelled)
 YHB.....houseboat
 YM.....dredge
 YMP.....motor mine planter
 YMS.....auxiliary motor minesweeper
 YNG.....gate vessel
 YO.....fuel oil barge (self-propelled)
 YOG.....gasoline barge (self-propelled)
 YOGN.....gasoline barge (nonpropelled)
 YON.....fuel oil barge (nonpropelled)
 YOS.....oil storage barge
 YP.....patrol vessel
 YPD.....floating pile driver
 YPK.....pontoon stowage barge

YR.....floating workshop
 YRB.....submarine repair and berthing barge
 YRBM.....submarine repair, berthing and mess-
 ing barge
 YRDH.....floating drydock workshop (hull)
 YRDM.....floating drydock workshop (machine)
 YRL.....covered lighter (repair)
 YSD.....seaplane wrecking derrick
 YSR.....sludge removal barge
 YTB.....large harbor tug
 YTL.....small harbor tug
 YTM.....medium harbor tug
 YTT.....torpedo testing barge
 YV.....drone aircraft catapult control craft
 YW.....water barge (self-propelled)
 YWN.....water barge (nonpropelled)

5.20 U.S. Army Marine Fleet Classification System

Each vessel in the transportation terminal battalion marine fleet bears an individual serial number, preceded by one of the following applicable prefixes.

BARC....lighter, amphibious (BARC), self-pro-
 pelled, diesel, steel, 60-ton, 61-foot,
 design 2303
 BC.....barge, dry cargo, nonpropelled, medium
 (100 feet through 149 feet)
 BCDK....conversion kit, barge, deck enclosure
 BCI.....barge, dry cargo, inland waterways, non-
 propelled, medium (100 feet through 149
 feet)
 BCLI....barge, dry cargo; inland waterways, non-
 propelled, large (150 feet and over)
 BCP.....barge, railroad carfloat
 BCS.....nested barge
 BD.....crane, floating
 BDL.....lighter, beach discharge
 BG.....barge, liquid cargo, nonpropelled
 BGI.....barge, liquid cargo, inland waterways, non-
 propelled
 BK.....barge, dry cargo, nonpropelled
 BKI.....barge, dry cargo, inland waterways, non-
 propelled
 BPL.....barge, pier, nonpropelled
 BR.....barge, refrigerated, nonpropelled
 BRI.....barge, refrigerated, inland waterways, non-
 propelled
 BRO.....barge, oil
 BSP.....barge, self-propelled
 BSPI....barge, self-propelled, inland waterways
 BT.....barge, training, nonpropelled
 F.....fireboat
 FB.....ferryboat
 FD.....drydock, floating
 FMS.....repair shop, floating, marine repair, non-
 propelled
 FS.....freight and supply vessel, large (140 feet
 and over)
 FSM.....freight and supply vessel, medium (100
 feet through 139 feet)

FSR.....freight and supply vessel, refrigerated
 cargo
 J.....boat, work and inspection, small (50 feet
 and under)
 LARC....lighter, amphibious, resupply, cargo
 LCM.....landing craft, mechanized (Mark VI, Mark
 VIII)
 LCR.....landing craft, retriever
 LCU.....landing craft, utility
 LCVP....landing craft, vehicle, personnel
 LT.....tug, large (100 feet and over)
 LTI.....towboat, large, inland waterways (100 feet
 and over)
 Q.....boat, work and inspection, large (over 50
 feet)
 R.....rowboat
 ST.....tug, small (99 feet and under)
 STI.....towboat, small, inland waterways (99 feet
 and under)
 T.....freight and supply vessel, small (under 100
 feet)
 Y.....vessel, liquid cargo, self-propelled

5.21 Vessel Deadweight Scale

a. Purpose. The vessel deadweight scale (fig. 5.17) is designed to furnish vessel tonnages and the effects of these tonnages on the mean draft of the vessel.

- (1) Column A represents the number of long tons that may be carried in the vessel, including fuel, stores, water, dunnage, and cargo, or any material that may be placed in the vessel, excluding equipment and machinery necessary for operation of the vessel.
- (2) Column B represents the vessel's mean draft in feet and inches. This scale is graduated from the least possible draft of 8 feet to a maximum draft of 29 feet.
- (3) Column C (displacement tonnage in salt water) represents the weight of the ship plus any material in or on the vessel.
- (4) Column D (tons per inch immersion) denotes the number of long tons required to lower the vessel 1 inch with any given draft.

b. Use. The deadweight scale is used by the cargo planner to determine the long tons that may be placed in a vessel to reach the required draft. For example, a vessel loaded with 9,000 long tons will have a mean draft of 25 feet 4½ inches at the beginning of the voyage and, using 50 long tons of fuel, stores, and water per day at sea, will have used 500 long tons through a period of 10 days, thus reducing the mean draft to 24 feet 6 inches. From these figures, the cargo planner can deter-

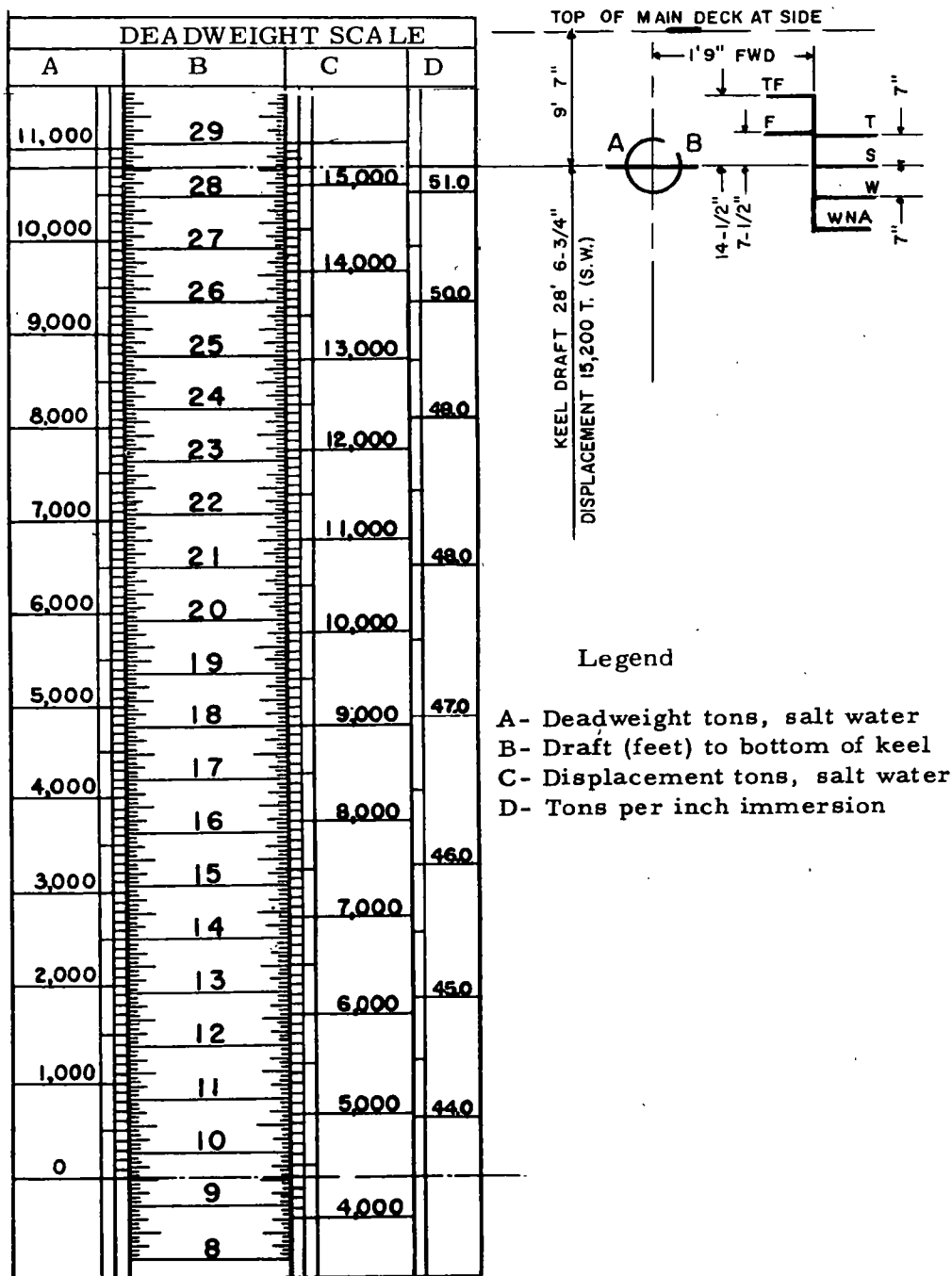


Figure 5.17. Deadweight scale for a Victory ship.

mine the vessel's draft at the completion of the trip, and he will know whether the draft is correct for the type of harbor where the cargo will be discharged.

c. *Cargo Deadweight Tonnage.*

- (1) In the deadweight column of the scale, the figure 0 is listed directly opposite the

light ship weight. The figures above 0 indicate weight added to the vessel in the form of fuel, stores, and cargo. All weight placed in the vessel increases the ship's mean draft and, by adding 10,805 long tons to the light ship, the vessel is forced down in the water to a maximum

mean draft of 28 feet 6¾ inches for sailing in summer salt water.

- (2) Certain complications may be involved in determining the cargo deadweight tonnage of the vessel. For instance, the ship may have a fixed ballast that is not entered in the deadweight scale. In such an event, the ship's officers add this to the number of tons of fuel, stores, and water that are on board. Also, they note the location of the ballast in the ship. This must be deducted from the deadweight tonnage, together with the fuel, stores, and water, to give a correct cargo deadweight tonnage. When the vessel

is at a mean draft of 28 feet 6¾ inches, summer salt water, it is in a condition known as displacement loaded, and, should weight in excess of 10,805 long tons be loaded in a light ship, it would be forced down in the water below the legal loadline for summer zone and would not be allowed to sail.

- (3) To prevent overloading the vessel, the weight of the fuel, stores, and water should be determined and deducted from the vessel deadweight tonnage to determine the maximum number of tons of cargo that may be placed in the vessel to bring it down to its marks.

Section III. TERMINAL AND WATER TRANSPORT OPERATIONS

5.22 Elements of Terminal Planning

a. In the planning data for terminal and related water transport operations, the basic period of time is a 20-hour working day. This is generally considered a complete round-the-clock working day for terminal operations; it is based on two 10-hour shifts. The remainder of the day is taken up in mealtime and shift changes. In forward areas, where enemy action may cause additional delays, 15 hours per day should be used as a planning figure. For general planning purposes, a transportation terminal service company (TOE 55-117) or its equivalent is considered capable of discharging 720 short tons per 20-hour working day. See also paragraph 5.26.

b. The three elements normally considered in terminal planning are:

- (1) Estimation of the existing terminal capacity or the total tonnage and personnel that can be received, processed, and cleared through the terminal in a day.
- (2) Determination of the terminal workload required to support the particular operation, expressed as target cargo tonnage and number of personnel per day.
- (3) Estimation of base development requirements necessary to increase the terminal capacity to meet the target

tonnage, including requirements for construction, equipment, and personnel.

5.23 Terminal Capacity

a. Terminal throughput capacity is determined by three major factors. In all instances, one of these is the limiting and thereby the determining factor. For planning purposes, each of the three factors may be expressed in terms of short tons per day. All three factors should be accurately estimated even though the limiting factor may be obvious. These estimates indicate the facilities where improvement effort will yield the greatest return in terms of tonnage-movement capability. The three major factors are:

- (1) Terminal reception capacity: the number and type of ships that can be moved into the harbor or coastal area of the terminal per day.
 - (2) Terminal discharge capacity: the number of ships that can be discharged in the terminal per day.
 - (3) Terminal clearance capacity: the amount of cargo and personnel that can be moved through and out of the terminal per day.
- b. A checklist for terminal capacity estimation is given below. Further information and procedures for estimating terminal capacity are provided in FM 55-8, FM 55-51, and FM 101-10.

Terminal Capacity Estimation Checklist

Collect these data:	Compute these factors:	To determine:
Channel depths.....	(1) Evaluate to determine water terminal reception capacity.	
Obstructions.....		
Enemy air activity.....		
Enemy surface activity.....		
Enemy submarine activity.....		
Climate and seasons.....		
Weather and tide characteristics.....		
Minefields or contaminated areas.....		
Capabilities in combating obstacles.....		
Tactical dispersion requirements.....		
Wharf facilities.....	(2) Evaluate to determine water terminal discharge (input) capacity.	Water terminal throughout capacity.
Beach capabilities.....		
Discharge rates ashore.....		
Discharge rates in the stream.....		
Anchorage area.....		
Extent of destruction or contamination.....		
Climate and seasons.....		
Weather and tide characteristics.....		
Cargo-handling equipment available.....		
Floating craft and equipment available.....		
Transit sheds and areas.....	(3) Evaluate to determine water terminal clearance (output) capacity.	
Availability of local labor.....		
Space reserved for local economy.....		
Enemy activity.....		
Capability of rail facilities.....		
Capacity of highway facilities.....		
Capacity of inland waterway facilities.....		
Capacity of pipeline facilities.....		
Capacity of air facilities.....		
Enemy activity.....		

5.24 Determination of Terminal Workload

The terminal workload is assigned by the theater commander and is the mission of a particular terminal. The mission assignment is a target tonnage based on the terminal's throughput capacity. Target tonnage consists of initial and anticipated tonnages. Initial tonnage is the amount of cargo the terminal organization is expected to handle before its capability is increased by base development. Anticipated tonnage is the amount of cargo required at a future specified date to support a particular operation and to build up a reserve supply for the support of future operations. When the target tonnage assignment is made, the terminal commander makes an estimate of the construction, equipment, and personnel required to increase the terminal capacity to handle the anticipated tonnage. The actual capability of the terminal is dependent upon its sustained ability to receive and clear the daily capacity over a period of time.

5.25 Wharf Facilities and Anchorage Areas

a. General. Terminal discharge capacity is the 1-day capacity of a terminal to accommodate ships in the harbor, to discharge them, and to clear the terminal of cargo. Considerations must include the harbor berths and anchorage areas available, wharf capacity, lighterage discharge, and local conditions. For general planning purposes, two methods of ship discharge are: discharge directly onto the wharf from vessels berthed alongside and discharge by lighterage from vessels anchored in the stream. Deep-draft wharfage must be provided wherever alongside discharge is contemplated, while shallow-draft wharfage and anchorage areas must be given joint consideration when lighter discharge is contemplated.

b. Berths and Anchorages. The first fact that must be determined is whether vessels can be brought into the anchorage areas and alongside the wharves. Berths and anchorages are evaluated according to the size of vessels they can accommodate.

(1) *Berth classifications.*

(a) *General berths.*

Class of general berths	Size vessel berthed			
	Length		Average draft	
	Feet	Meters	Feet	Meters
A-----	Over 500	Over 152	30	9.2
B-----	500 to 460	152 to 140	26	7.9
C-----	460 to 350	140 to 107	19	5.8
D-----	350 to 250	107 to 76	16	4.9
E-----	250 to 200	76 to 61	12	3.6
F-----	Under 200	Under 61	Under 12	Under 3.6

(b) *Tanker berths.*

Class of tanker berths	Size vessel berthed			
	Length		Average draft	
	Feet	Meters	Feet	Meters
T-A-----	600 and over	183	33	10
T-B-----	525	160	30	9.2

(b) *Standard classification system.*

Class	Diameter		Depth of water		Type of vessel
	Yards	Meters	Feet	Meters	
I	Over 800-----	Over 732-----	Over 38-----	Over 12-----	Capital naval ship or large passenger ship.
II	500 to 800-----	457 to 732-----	30 to 38-----	9 to 12-----	Standard oceangoing vessel
III	Under 500-----	Under 457-----	Under 30-----	Under 9-----	Destroyer or small cargo vessel

c. Wharf Capacity. Terminal capacity estimates are based on the use of all available wharf facilities. All facilities suitable for handling general cargo should be included in the estimate—for example, open or covered terminals, naval wharves, ship-repair and fitting-out wharves, bulk-cargo wharves, and special-purposes wharves. If the use of a particular wharf is doubtful and its capacity has been included in the estimate, a clarification should be given. Wharf capacity is materially affected by the factors discussed below.

- (1) *Type.* The type of wharf must be considered by the analyst. The general term "wharf" includes both quays and piers. A quay is a wharf parallel with the shoreline of a basin or harbor with water and accommodations for ships on one side only. A pier is a wharf which projects into the harbor or basin with

Class of tanker berths	Size vessel berthed			
	Length		Average draft	
	Feet	Meters	Feet	Meters
T-C-----	450	137	25	7.6
T-D-----	250	76	13	4
T-E-----	Under 250	Under 76	Under 13	Under 4

¹ Most modern ocean-going tankers will arrive with drafts of 30 feet and over. Commercial supertankers with drafts 35-45 feet are becoming common.

(2) *Anchorage berths.*

(a) *Anchorage berth diameter formulas.*

The following formulas are used to find the diameter for anchorage berths:

$$\frac{2(7D \times 2L)}{3} = \text{diameter in yards}$$

$$(0.61)(7D \times 2L) = \text{diameter in meters}$$

where

D = depth of water in feet

L = length of vessel in feet

water and accommodations for ships on both sides. There are several kinds of piers, such as T-head, L-head, and marginal.

- (2) *Layout.* The analyst must also consider the layout of the facility. This includes adequacy of approaches, stacking space on the landward side, raised or depressed tracks, curbs, fences, deck surfacing material, transit-shed space, number and size of transit-shed doors, and the depth of high and low water alongside.
- (3) *Weather.* Weather, particularly during extreme conditions, has a direct bearing on the use of estimated capacity of a wharf.
- (4) *Alinement.* The alinement of the face of the wharf is an important factor. The angle points and curvatures along the

wharf face must be considered. If they are excessive, the usable linear footage must be reduced appropriately.

(5) *Deck.*

- (a) *Load capacity.* The load capacities of the wharf deck and of the transit shed floor are of prime importance. A rule-of-thumb method for determining the adequacy of the load capacity is the present use of the wharf. If it is known that a certain cargo is normally handled, a fair load-capacity evaluation may be made.
- (b) *Height.* The height of the wharf deck must be considered in relation to the tidal rise. Generally, a wharf should be at least 5 feet (1.5 meters) above high-tide level.
- (c) *Working space.* The working space is determined by the type of wharf, the length and width of the wharf apron, the wharf's decking, and its exits. The working space must be wide enough to allow general cargo to be unloaded and cleared without undue delay. Dimensions shown below can be used in planning. Local customs, specialized wharves, and unusual construction may permit variations in these figures.

1. *Wharf length.* For planning purposes, 100 feet (30 meters) of wharf is required for each hatch or each lighter to be discharged. The discharge rate (par. 5.26 below) for ships and coasters is reduced 20 to 25 percent for each 100-foot reduction in wharf length under the minimum required. In determining lighterage facilities, length more than 100 feet but less than the next 100-foot unit is disregarded. For example, a 150-foot (45-meter) wharf accommodates only one lighter; a 250-foot (75-meter) wharf accommodates two lighters, etc.

2. *Wharf width.* A wharf working area of at least 60 feet (18 meters) is necessary for proper cargo handling and shipside clearance when discharging from only one side of a wharf. When both sides of a wharf are used simultaneously, each side

should have a 45-foot (14-meter) working space.

- (d) *Depth alongside.* Fluctuations in tide levels affect the discharge of cargo, especially where tidal variation is great and ships need the advantage of high tides to reach their berths. If the wharves are not located in wet docks and if the tidal variations are extreme, the discharge-capacity estimate should be adjusted to reflect this condition. The effective terminal discharge capacity may be reduced as much as 50 percent if alongside depths are reduced below the operable minimum by the tidal range. Under normal conditions, the water should be at least 30 feet (9 meters) deep at low tide. (A minimum of 30 feet is used for planning purposes because this depth accommodates virtually all deep-draft dry-cargo vessels.)
- (e) *Physical condition.* Physical condition must be considered when the usefulness of a wharf is evaluated, for deterioration or damage may limit its capacity.

d. *Lighterage Discharge.* Wharves used by lighters should be within a reasonable distance of a sufficient number of anchorages and moorings. Lighterage berths are assigned in units of 100 feet (30 meters) for each lighter (taken to the nearest 100 feet). This unit measurement must be used realistically—length of wharf more than 100 feet but less than the next 100-foot unit is disregarded (a 350-foot (107-meter) wharf accommodates three lighters at the same time). All alongside berths with depths of less than 18 feet (5.5 meters) are considered lighter berths.

e. *Local Conditions.* Conditions may vary with localities and sometimes may be very unusual. When necessary, berth, wharf, and lighter discharge factors must be adjusted or reduced to meet emergencies imposed by local conditions.

5.26 Discharge Rates

a. *Commercial-Type Loading.* For planning purposes, the average ship is considered to be 450 feet long and 60 feet wide with five hatches, the average coaster 350 feet long and 35 feet wide with four hatches, and the average lighter 100 feet long and 35 feet wide. This excludes landing craft and amphibians. The figures given below for ships and coasters in the stream indicate tonnage dis-

charged from the ship or coaster into lighters. The limiting factors are the number of lighters available and the wharf space provided for their discharge. Number of lighters required is based upon the number of hatches, the size of the lighters, and the turnaround time. The following discharge rates are based on average sizes of the type of vessels indicated.

- (1) Average ship, alongside or in stream—720 short tons or 643 long tons per 20-hour day.
- (2) Average coaster, alongside or in stream—500 short tons or 446 long tons per 20-hour day.
- (3) Average lighter alongside wharf—180 short tons or 160 long tons per 20-hour day.

b. Specialized Loading. When maximum unloading efficiency is the governing factor rather than economy of cargo space, the principles of combat loading should be employed. For this specialized loading, mixture of cargo types within ships' holds should be kept to a minimum, and each hatch must be self-sustaining.

- (1) Stowage of cargo should be blocked vertically in each hatch; this saves time by reducing the number of times the cargo gear must be rerigged or shifted. Within each cargo space, drafts of cargo should be palletized, netted, or containerized; they should not be tiered unless MHE is available to move cargo from the wings to the hatch square. When cargo is palletized, at least four pallets in each hatch square should have bridles intact so that no time will be wasted in breaking the stowage.
- (2) Vehicles should not be floored over and tiered, even if space is available, as bulling vehicles to the square on the upper tier and clearing the flooring and shoring is time consuming. So far as possible, trailers should be stowed with their prime movers. Unit cargo may be loaded in vehicles to the lowest reducible height if the cargo-gear capacity is not exceeded. Powered vehicles must be in running condition with fuel tanks three-quarters full.
- (3) Unloading time for each hatch is computed at time of prestowage, using a profile loading diagram (fig. 5.18) for the ship. The profile loading diagram may

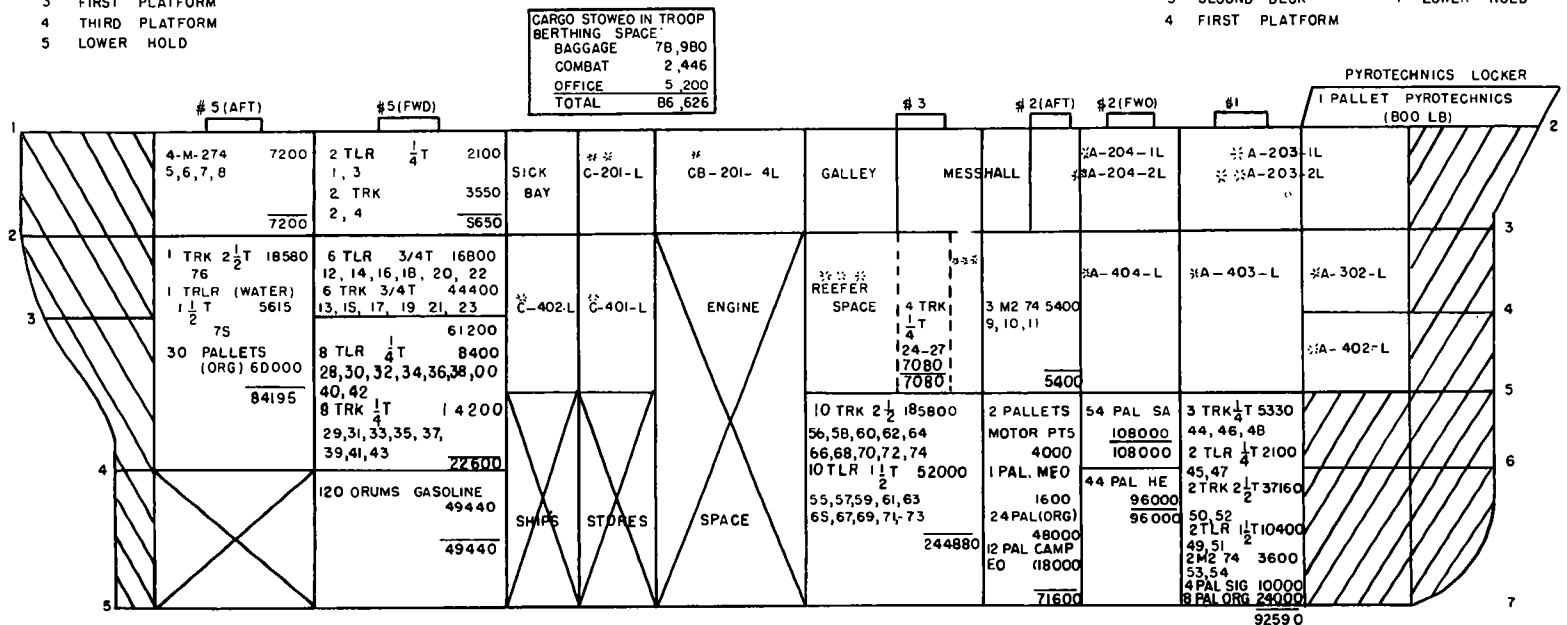
be filled out from the information in the stowage plan. Time factors for hatch opening, shift of gear, and all drafts are added to obtain the total unloading time for each hatch. This total is entered in the tabulation for the hatch on the profile loading diagram.

- (4) Rig and boom capacities differ among hatches for each design of cargo vessel. In general, 5-ton booms are installed to serve each hatch and one or more hatches are also served by jumbo booms of from 30- to 60-ton capacity. The limiting load factor of the rig is the safe working load of the wire rope multiplied by the number of parts. The normal safe load for a single-rigged yard-and-stay rig is 6,600 lb for $\frac{5}{8}$ " wire and 8,800 lb for $\frac{3}{4}$ " wire (improved plow steel) in good condition. Heavier weights must be lifted by doubled yard-and-stay rigs, swinging booms, four-boom rigs, or jumbo booms.
- (5) Average weights of drafts:
 - (a) Palletized general cargo—1 ST
 - (b) Palletized ammunition— $1\frac{1}{2}$ ST
 - (c) CONEX—5 ST
 - (d) Vehicle weights depend upon type and preloading.
- (6) Unloading time can be computed by using the following factors as guidance:
 - (a) Single rigged yard-and-stay, 5 minutes per draft (pallets, $\frac{1}{4}$ -ton trucks and trailers, $1\frac{1}{2}$ -ton trailers, empty $\frac{3}{4}$ -ton trucks).
 - (b) Doubled yard-and-stay, or double-purchase swinging-boom rig, 10 minutes per draft (CONEX, empty $2\frac{1}{2}$ -ton truck).
 - (c) Jumbo-boom rig, 15 minutes per draft (vehicles heavier than $2\frac{1}{2}$ -ton truck, APC, tanks).
 - (d) To open hatch, 15 minutes average (25 minutes for weatherdeck hatch; 10 minutes for 'tween-deck hatch).
 - (e) To shift rig, 30 minutes.
- (7) Unloading time estimates for specially equipped vessels, such as RO/RO, LPH, and LPD equipped with special ramps, elevators, pallet conveyors, monorails, or other devices, must be developed from experience gained during loading or from records kept on the vessel.
- (8) Detailed guidance on combat loading,

- 1 MAIN DECK
2 SECOND DECK
3 FIRST PLATFORM
4 THIRD PLATFORM
5 LOWER HOLD

U.S.S. FREMONT (APA 44)

- 1 FOC'SLE DECK
2 MAIN DECK
3 SECOND DECK
4 FIRST PLATFORM
5 SECOND PLATFORM
6 THIRD PLATFORM
7 LOWER HOLD



HOLD SECT NO	NO 5 (AFT)	NO 5 (FWO)	BERTHING SPACE	NO 3	NO 2 (AFT)	NO 2 (FWO)	NO 1	PYRTECHNICS
NUMBER OF LIFTS	36	47	- -	24	42	98	23	
SHORT TONS	45.6	66.6	43.3	1224	38.5	102	47.7	0.4
ESTIMATED UNLOADING TIME (MINUTES)	240	485	- - -	365	270	535	245	--
TOTAL SHORT TONS. 466.5	*DENOTES TROOP ENLISTED BERTHING SPACE **DENOTES TROOP OFFICER BERTHING SPACE ***DENOTES REFRIGERATED CARGO SPACE							

Figure 5.18. Profile loading diagram.

commodity loading, and selective loading is contained in FM 60-30. Profile loading diagrams for amphibious force vessels, as well as standard maritime commission design vessels, are obtained from the amphibious force of the nearest U.S. Navy fleet.

5.27 Temporary Storage Areas

To plan for temporary storage areas for cargo, use the figures given below.

a. *Open Storage.* Approximately 10,000 square feet of open storage area is required for each 560 short tons, or 500 long tons, or 1,000 measurement tons of cargo. Average stack height should be 6 feet.

b. *Covered storage.* Approximately 8,000 square feet of covered storage area is required for each 560 short tons, or 500 long tons, or 1,000 measurement tons of cargo. Average stack height should be 8 feet. Generally, 10 percent of 1 day's target tonnage will require covered storage.

5.28 Personnel and Equipment Requirements

For planning purposes, one terminal service company (TOE 55-117) or its equivalent in personnel and equipment is required for each ship berth in a water terminal or for each 720 short tons of the terminal's daily capacity. Paragraph 5.25 above lists the factors for determining ship berth space.

5.29 Estimating Water-Terminal Capacity

The following example demonstrates the recommended procedure for estimating water-terminal capacity based upon the steps and data outlined in the preceding paragraphs and using the harbor chart shown in figure 5.19.

a. Wharf Facilities.

Wharf No.	Length		Width		Minimum depth alongside	
	Feet	Meters	Feet	Meters	Feet	Meters
1	1,060	323	80	24.4	32	9.8
2	490	150	60	18.3	30	9.2
3	580	177	90	17.4	30	9.2
4	535	163	100	30.5	34*	10.4*
5	125	38	54	16.5	8	2.4
6	295	90	60	18.3	15	4.6
7	450	137	75	22.9	22	6.7
8	210	64	60	18.3	16	4.9

* Each side

b. Anchorage Areas.

- (1) There is sufficient area inside the harbor

to anchor three ships where they can be worked continuously.

- (2) In good weather, two vessels can be anchored and worked outside the breakwater.
- (3) Winds, swells, tides, and tidal currents present no unusual problems.

c. Discharge Tonnage.

- (1) *At deep-draft wharfage.*

Wharf No.	Victory ship berths	Discharge rate (ST per day)
1	2	$2 \times 720 = 1,440$
2	1	$1 \times 720 = 720$
3	1	$1 \times 720 = 720$
4	2	$2 \times 720 = 1,440$
Total.....		4,320

- (2) *At lighterage wharves.*

Wharf No.	Lighter berths	Discharge rate (ST per day)
5	1	$1 \times 180 = 180$
6	*3	$3 \times 180 = 540$
7	4	$4 \times 180 = 720$
8	2	$2 \times 180 = 360$
Total.....		1,800

- (3) *Alternate method.* If only the total length of wharfage is known, this length in feet may be multiplied by 1.2 for alongside discharge and by 1.4 for lighterage discharge. The quantities thus obtained are conservative planning figures; they are expressed as long tons discharged per day.

d. *Rate of Discharge From Ships at Anchor to Lighters.* According to the chart, three ships can be anchored inside the breakwater, and two can be anchored and worked outside the breakwater in good weather. Therefore, in good weather, cargo can be discharged from ships to lighters at the rate of $(3 + 2) \times 720 = 3,600$ short tons per day.

e. Summary of Daily Terminal Capacity.

- (1) Discharged alongside deep-draft wharves—4,320 short tons per day.
- (2) Discharged from lighters to wharves—1,800 short tons per day.
- (3) Transferred from ships to lighters—3,600 short tons per day.
- (4) The maximum discharge per day is 1,800 short tons because lighter wharfage is the limiting factor (par. 5.23a). Therefore the total daily terminal capacity is 6,120 short tons: 4,320 short tons alongside; 1,800 short tons by lighter.

* Wharf No. 6 is only 295 feet long. In paragraph 5.25 three ships require 300 feet. However, the 5-foot shortage will not affect operations appreciably and three lighters are docked here.

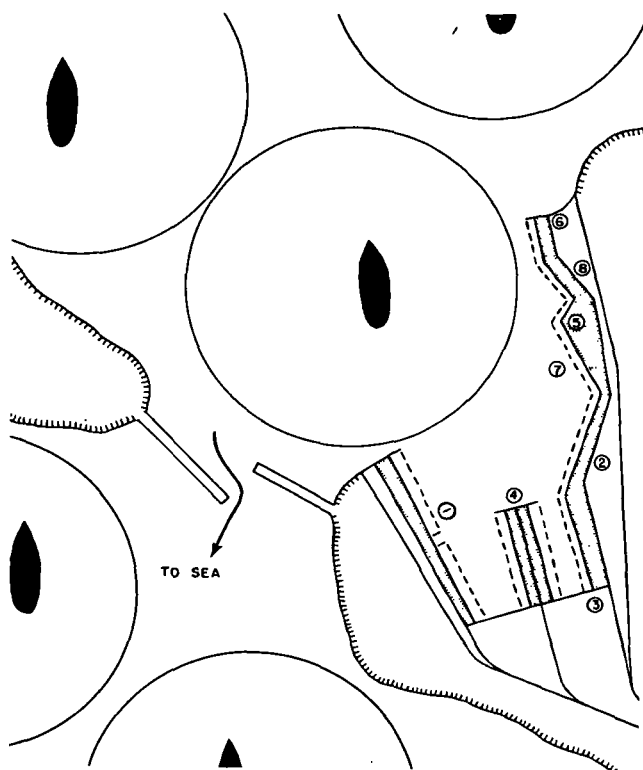


Figure 5.19. Harbor chart for terminal capacity estimation.

f. Personnel and Equipment Requirements. Personnel and equipment requirements to maintain the above daily tonnage figure may be determined by dividing 6,120 short tons by 720 short tons (daily terminal service company discharge capability). Therefore, nine terminal service companies (TOE 55-117) or their equivalent in personnel and equipment and the necessary light-erage support will be required to maintain the discharge capacity of this terminal.

g. Weather Considerations. Advance study must be made to determine the probable effect of bad weather on the rate of discharge and other factors in water terminal capacity. Continuous records of daily discharge plotted against weather and surf conditions prove valuable in planning future discharge at the same and similar terminals.

5.30 Inland Waterways Service

a. The use of inland waterways for military purposes is normally envisaged only in under-developed areas in which alternate modes are either lacking or insufficient. These waterways are to be used principally for civilian traffic and for the restoration of the local economy. Further, it is assumed that rehabilitation of these waterways

will be undertaken by local authorities and that a minimum of military effort will be diverted for the purpose, except where designated for immediate military use and equipment salvage. Inland waterways can be used to relieve the pressure on other modes of transportation; they are especially useful for moving nonperishable supplies.

b. When required, an inland-waterway service may be formed to control and operate a waterway system, to formulate and coordinate plans for using inland-waterway transport resources, and to provide for the integration and supervision of local civilian facilities used in support of military operations. This operational organization may vary in size from a single barge crew to a complete inland-waterway service, depending upon the requirements. It may be composed entirely of military personnel or may be manned by local civilians supervised by military units of the appropriate transportation staff section.

c. Although an inland-waterway service may be operated by a terminal command, a terminal battalion composed of appropriate terminal service, harbor craft, boat, and/or amphibian units will most often be employed in this capacity. A typical inland-waterway organization is shown in figure 5.20.

5.31 Estimating Inland-Waterway Capabilities

When determining the capability of an inland waterway, the following must be considered:

- a.* Restricting widths and depths of channel.
- b.* Vertical and horizontal clearance of bridges.
- c.* Location of dams or other bars to navigation.
- d.* Location of locks; dimensions, timing, method of operation, and other limiting factors.
- e.* Frequency, duration, and effect of seasonal floods and droughts.
- f.* Normal freezeup and opening dates.
- g.* Navigation hazards—rapids, falls, etc.
- h.* Speed and fluctuation of current.
- i.* Waterway maintenance requirements.
- j.* Changes of channel.
- k.* Availability of civilian and/or military craft.
- l.* Availability of skilled bargemen, pilots, and tugboat operators from civilian and/or military sources.
- m.* Number of terminals.
- n.* Terminal facilities, including wharves, cranes, materials handling equipment, marine maintenance shops, and port clearance.

o. Ability of the waterway to displace its capacity daily over a considerable period of time.

5.32 Determination of Inland-Waterway Movement Capability

a. *General.* The actual capacity of a waterway, the availability of craft, and the adequacy of terminal facilities are factors that must be considered when estimating inland-waterway movement capability. Any of these factors may limit an inland-waterway operation; each one must be examined to determine its impact upon the waterway-movement capability. It is necessary, in the absence of definite information, to make certain assumptions when making an actual estimate of inland-waterway movement capability.

b. *Assumptions.* It is assumed that:

- (1) Waterway is useable.
- (2) Weather is favorable.
- (3) Civilian use of the waterway has been suspended.
- (4) Manpower and fuel are available and adequate.
- (5) Vessels are weight-loaded to 60 percent of capacity.
- (6) Average deadline rate is 20 percent.
- (7) Waterway operations are 15 hours per day.
- (8) Average speed is 4 miles per hour (6.4 kmph).
- (9) Port operations are 20 hours per day.
- (10) Cargo handling averages 30 tons per hour per barge.
- (11) Average locking cycle is 45 minutes.
- (12) Empties pass through the locks on the return trip.
- (13) Effect of current is ignored.
- (14) Cargo movement is only in one direction.

c. *Waterway Movement Capability.* There are two types of waterways—open and restricted. In this discussion, lakes, rivers, channels, canals, and other navigable inland bodies of water without locks or other restrictive features are “open waterways,” while waterways with locks or other restrictive features are “restricted waterways.” The actual movement capability of the waterway depends upon the length of time that the daily capacity can be maintained.

- (1) *Open waterways.* In general, open waterways can accommodate a large volume of traffic. The Mississippi River is an example of such a waterway: tows on the Mississippi and Ohio Rivers are usually

$\frac{1}{4}$ -mile long. Movement is limited only by availability of craft and adequacy of terminal facilities.

- (2) *Restricted waterways.* An inland waterway that has locks or other restrictive features, such as narrow bridge spans or narrow passageways, is a restricted waterway. A narrow passageway or narrow bridge span may be the most limiting factor in an inland-waterway movement. For example, if there is only one under-bridge passageway, the safe distance between tows is the governing factor. The safe distance between tows may vary from 1,000 to 2,000 feet (305 to 610 meters). Changing the number of tows per mile can make a great difference in movement capability.

- (3) *Capacity formulas.*

(a) *General.* The formulas given below may be used to determine movement capability over waterways. In these formulas and in the formulas for determining barge and tug requirements discussed in *d* below, the letters used have the following meanings:

- A = number of barges
- B = tons per barge
- C = percentage of useable barges
- D = factor for military loading.

(This is the reduction factor that must be applied to each operation: it is determined by the loading and unloading of personnel, equipment, and facilities available.)

E* = one-way distance in miles or kilometers

F = navigating-operating hours per day

G* = average speed in miles or kilometers per hour

H = actual load of one barge in tons

I = port-handling rate in tons per hour

J = length of port-working day in hours

K = number of locks

* If metric system is used, it must be adhered to for both distance and speed.

L = length of longest locking cycle in minutes

M = lock-operating hours per day

N = tows per mile

O = number of passages per day

P = daily tonnage requirement

Q = turnaround time in days for barges

R = number of barges per tow

S = turnaround time in days for tugs

- (b) *Turnaround time.* The turnaround time in days for barges and tugs used in the formulas is the sum of navigating time, port time, and lock time. Methods of determining these times are:

$$\text{Navigating time} = \frac{E \times 2}{F \times G}$$

$$\text{Port time} = \frac{H \times 2}{I \times J}$$

$$\text{Lock time} = \frac{K \times L}{M \times 60}$$

- (c) *Formula for open waterway.* A simple formula applicable only to open waterways is—

$$\text{Capacity in tons per day} = N \times G \times F \times B \times D$$

- (d) *Formula for restricted waterway.* When the waterway is restricted but the number of possible passages per day is known, a simple formula is—

$$\text{Capacity in tons per day} = B \times O \times D$$

- (e) *Formula for both open and restricted waterways.* If the number of possible passages per day is not known, but the basic information (information represented by the letters A through M in (a) above) is available, the following formula may be used for an open or restricted waterway.

Capacity in tons per day =

$$\frac{A \times B \times C \times D}{\frac{E \times 2}{F \times G} + \frac{H \times 2}{I \times J} + \frac{K \times L}{M \times 60}}$$

Example: How many tons of military stores per day can be moved on a 300-mile (483-kilometer) waterway that has 10 locks if—

One hundred 1000-ton capacity, self-propelled barges are available.

The percentage of useable barges is 80.

The factor for military loading is 0.6.

Navigating-operating hours per day are 15.

Average speed is 4 miles per hour (6.4 kmph).

Load of each barge is 600 tons.

Port-handling rate per hour is 30 tons.

Length of port-working day is 20 hours.

The locking cycle is 45 minutes.

Lock-operating hours per day are 15.

$$\begin{aligned} \text{Capacity} &= \frac{100 \times 1000 \times .80 \times 0.6}{\frac{300 \times 2}{15 \times 4} + \frac{600 \times 2}{30 \times 20} + \frac{10 \times 45}{15 \times 60}} \\ &= 3,840 \text{ tons per day} \end{aligned}$$

d. Availability of Craft.

- (1) *Barges.* Barge requirements can be determined after the route capability is computed or after the daily tonnage requirements are established. The formulas given below may be used to determine the number of barges required for open and restricted waterways.

(a) *Open waterway.*

$$\text{Barges required} = \frac{P \times Q}{B}$$

(b) *Restricted waterway.*

$$\text{Barges required} = O \times Q$$

- (2) *Tugs.* When tugs are used, the arrangement of the tows must be considered. It is sometimes possible to operate with fewer tugs than tows because the tugs do not have to wait in port while the cargo is being transferred. Moreover, one tug can often tow more than one barge. In planning a towing operation, the fit of the tow in the locks must be considered. The following formula can be used to determine the number of tugs or towboats required to move the available barges.

$$\text{Number of tugs or towboats required} = \frac{A \times S}{R \times Q}$$

e. *Adequacy of Terminal Facilities.* Port facilities include berthing space and cargo handling equipment. Generally, lack of terminal facilities

additional facilities cannot be improvised, the existing port facilities may be the most restrictive factor in the entire movement. In such a case, the capacity of port facilities determines the inland-waterway movement capability. This problem cannot be solved by using formulas; its solution requires careful analysis and sound judgment.

Checklist for estimation of inland terminal throughput capacity.*

To determine:

Channel depths.....	(1) Evaluate to determine inland terminal reception capacity.	
Obstructions.....		
Capacity of rail facilities.....		
Capacity of highway facilities.....		
Capacity of pipeline facilities.....		
Capacity of air facilities.....		
Enemy air activity.....		
Enemy surface activity.....		
Climate and seasons.....		
Weather and tide characteristics.....		
Contaminated areas.....		
Capabilities in combating obstacles.....		
Tactical dispersion requirements.....		
Wharf and/or platform facilities.....		
Discharge rates.....		
Unloading rates.....		Inland terminal throughput capacity.
Loading rates.....		
Extent of destruction or contamination.....		
Climate and seasons.....	(2) Evaluate to determine inland terminal discharge (input) capacity.	
Weather and tide characteristics.....		
Materials-handling equipment available.....		
Cargo-handling equipment available.....		
Floating craft and equipment available.....		
Airfield capabilities.....		
Transit sheds, yards, and areas.....		
Local labor available.....		
Space reserved for local economy.....		
Capacity of rail facilities.....		
Capacity of highway facilities.....		
Capacity of inland-waterway facilities.....		
Capacity of pipeline facilities.....	(3) Evaluate to determine inland terminal clearance (output) capacity.	
Capacity of air facilities.....		

Type of cargo	Percent of total cargo	Type of cargo	Percent of total cargo
Sea shells.....	5.27	Clays and earths.....	.51
Animal products (inedible).....	.22	Sulphur.....	.72
Grain and grain products.....	1.34	Limestone.....	.81
Coffee, raw or green.....	.04	Salt.....	.09
Sugar.....	.23	Sand, gravel, crushed rock.....	13.30
Molasses.....	.23	Iron and steel.....	2.43
Soybeans.....	.32	Aluminum ores and scrap.....	.05
Logs.....	5.35	Copper ores and scrap.....	.09
Lumber and lumber products.....	.49	Construction and mining machinery.....	.09
Pulpwood.....	.48	Motor vehicles and parts.....	.13
Woodpulp.....	.10	Coal tar products.....	.35
Paper and paper products.....	.31	Sulphuric acid.....	.47
Anthracite coal.....	.30	Industrial chemicals.....	.74
Bituminous coal and lignite.....	25.00	Fertilizer.....	.13
Coke.....	.14	Chemical products, miscellaneous.....	.01
POL.....	34.50	Miscellaneous.....	5.23
Building cement.....	.48		

b. Depths, Navigable Distances, and Average Freight for Principal Waterways.¹

Controlling low-water depths (ft)	Mississippi River system	Atlantic Coast rivers	Pacific Coast rivers	Gulf Coast rivers ²	Rivers emptying into Great Lakes	Federal canals and connecting channels	State and private canals	Gulf intra-coastal (Apalachee Bay, Fla., to Mexican border)	Florida west coast	Atlantic intra-coastal (Norfolk, Va., to Key West, Fla.)	Miscellaneous
Navigable Statute Miles and Kilometers ³											
Less than 3.....	3,626 (5,840)	1,125 (1,810)	757 (1,220)	1,328 (2,140)							
3-6.....	2,297 (3,700)	1,340 (2,160)	540 (860)	1,343 (2,160)		500 (805)					800 (1,288)
6-9.....	1,988 (3,200)	900 (1,450)	555 (893)	968 (1,560)		1,077 (1,735)			103 (166)	562 (904)	
9-12.....	4,612 (7,410)	539 (868)	98 (158)	634 (1,020)	17 (27.4)	801 (1,289)	171 (276)			18 (29)	
Over 12.....	249 (401)	1,805 (2,900)	248 (400)	24 (38.6)	121 (195)	710 (1,140)	525 (845)	1,116 (1,795)		1,398 (2,250)	
Freight											
Average annual short-ton miles (in millions).....	45,780	2,146	1,961	636		15,074	12	27		4	

¹ Great Lakes not included.

² Mississippi River not included.

³ Quantities in parentheses represent kilometers.

c. Important Waterways, Terminals, Critical Distances, Depths, and Cargo. The table below gives general planning information for inland-waterway transportation in the United States. Some of the important waterways and terminals are shown, and typical commercial cargo is included since this could be of interest to a strategic planner. When a move on an inland waterway is contemplated, the planner should obtain a large-scale hydrographic map and plan the move in detail.

Name of waterway	Principal terminals	Critical distances	Controlling depths for specified locations	Typical cargo carried commercially
Allegheny River.....	Pittsburgh, Pa., New Kensington, Pa., Kittanning, Pa., East Brady, Pa.	325 miles (523 km) from its rise in northern Pennsylvania to its mouth at Pittsburgh	9 feet for improved portion, Pittsburgh, to above East Brady, 72 miles (116 km); no	Coal, coke, sand, gravel, POL and POL products, glass, furnace slag, lignite crushed

Name of waterway	Principal terminals	Critical distances	Controlling depths for specified locations	Typical cargo carried commercially
		where it joins the Monongahela River to form the Ohio River. The Allegheny River consists of two sections: the improved portion (locks and dams), Pittsburgh, to above East Brady, Pa., 72 miles (116 km); and the open channel (unimproved) portion above East Brady, Pa.	specific depths for open channel portion (unimproved) above East Brady.	rock, nonmetallic minerals and products, iron and steel, iron ore, industrial chemicals.
Atlantic intracoastal waterway.	Norfolk, Va., Elizabeth City, N. C., Washington, N. C., Georgetown, S. C., Charleston, S. C., Savannah, Ga., Jacksonville, Fla., Palatka, Fla., Sanford, Fla., St. Augustine, Fla., Daytona Beach, Fla., West Palm Beach, Fla., Miami Beach, Fla.	The main route extends 1,262 miles (2,300 km) from Norfolk to Key West, Fla., with a 65-mile (104.5 km) alternate channel, known as the Dismal Swamp Canal Route (west of, and generally parallel to, the main route) extending south from Norfolk, through the Southern Branch of Elizabeth River, Deep Creek, Dismal Swamp Canal, Turners Cut, and Pasquotank River to its junction with the main route at the mouth of the Pasquotank River on Albermarle Sound, S. C.	(1) <i>Main route</i> : 12 feet from Norfolk, to the Va.-N. C. state line, 27 miles (43.3 km); 10 feet from Va.-N. C. line to Little River, S. C., at N. C.-S. C. state line, 308 miles (496 km); 10 feet from Little River to Port Royal Sound, S. C. (near Beaufort), 210 miles (338 km); 9 feet from Port Royal Sound, to Fernandina, Fla. (Cumberland Sound), 165 miles (266 km); 12 feet from Fernandina to St. John River, Fla. (Jacksonville), 22 miles (35.4 km); 12 feet from Jacksonville to Eau Gallie, Fla., 198 miles (319 km), except for several shoals with limiting depth of 7.8 feet; 8 feet from Eau Gallie to Miami, 174 miles (280 km); 6.5 feet from Miami, to Cross Bank, Fla., 64 miles (103 km); 5 feet from Cross Bank to Key West, Fla., 94 miles (151 km). (2) <i>Dismal Swamp Canal route</i> : 8.6 feet in Deep Creek, Va., 3 miles (4.83 km); 6.7 feet in Dismal Swamp Canal, Va. and N. C., 22 miles (35.4 km); 9.2 feet in Turners Cut, N. C., 5 miles (8.05 km); and 9.4 feet in Pasquotank River, N. C., 35 miles (56.4 km).	Logs, paper pulp, sand, gravel, fish, POL and POL products, fertilizer, pulp, acid phosphate, paperboard and pulpboard, sea food, seashells, automobiles, grain and grain products, sugar, soybeans, limestone, salt, iron and steel, industrial chemicals.

Name of waterway	Principal terminals	Critical distances	Controlling depths for specified locations	Typical cargo carried commercially
Black Warrior, Warrior, and Tombigbee River System	Birmingham, Ala., Tuscaloosa, Ala., Demopolis, Ala., Mobile, Ala.	The Black Warrior and Warrior Rivers, a single stream, rise in northern Alabama above Birmingham and unite with the Tombigbee River at Demopolis. From there the Tombigbee flows south, uniting with the Alabama River to form Mobile River 45 miles (72.4 km) above the head of Mobile Bay. The distance by water from Mobile to the vicinity of Birmingham is about 415 miles (668 km).	9 feet from Mobile to Mile 444.6 on Mulberry Fork, Mile 447.6 on Sipsey Fork, and Mile 420.6 on Locust Fork of the Black Warrior River.	Iron ore, manganese ore, sulphur, coal, POL and POL products, clay and bentonite, logs, stone and rock, pulpwood, iron and steel articles, cast iron pipe and fittings, sea shells, molasses, lignite, cement, limestone, sand, gravel, iron ore concentrates, nonferrous metals and scrap, industrial chemicals.
Calumet-Sag Channel.	Blue Island, Ill.-----	23.8 miles (38.3 km) from its junction with the Chicago Sanitary and Ship Canal to Blue Island, the Little Calumet Rivers to Turning Basin No. 5.	9 feet for entire length--	Grain and grain products, soybeans, coal and lignite, POL and POL products, sulphur, sand, gravel, crushed rock, iron and steel, manganese, iron ore.
Chesapeake Bay system (James, York, Rappahannock, and Potomac Rivers)	Norfolk, Va., Newport News, Va., Richmond, Va., Fredericksburg, Va., Washington, D. C., Baltimore, Md., Cumberland, Md.	-----	-----	Logs, paper pulp, POL, fish, fertilizer, sea shells, sea food, phosphate, pulpwood, automobiles, coal, coke, sand, gravel, sugar, lumber and shingles, lignite, sulphur, non-metallic minerals, iron and steel, sulphuric acid, industrial chemicals, paper and paper products, naval stores.
Columbia River----	Astoria, Ore., Vancouver, Wash., Portland, Ore., The Dalles, Ore., Kennewick, Wash., Rickland, Wash.	Mouth to Canadian border, 745 miles (1,200 km).	33 feet or deeper between mouth of Columbia River and mouth of Willamette River (Mile 101.5); 30 feet to Interstate Bridge, Vancouver, Wash. (Mile 106.5); 15 feet from Vancouver to Bonneville, Ore. (Mile 145.3); 24.2 feet over miter sills at Bonneville Lock and Dam; 20 feet from Bonneville to The Dalles-Celilo Canal (Mile 191); 7 feet through The Dalles-Celilo Canal; 7 feet from Celilo, Ore. (Mile	Grain and grain products, coal tar products, vegetables and fruits, sawmill products, sand and gravel, coal, sea food, stone and rock, POL and POL products, sulphur, logs, hogged fuel, lumber, shingles and lath, iron and steel articles, iron and steel pipe and fittings, woodpulp, newsprint paper, printing paper, paper and paper articles, wrapping paper, canned foods, cement, salt, crushed rock, chemicals and

Name of waterway	Principal terminals	Critical distances	Controlling depths for specified locations	Typical cargo carried commercially
			201) to McNary Lock and Dam, Ore. (Mile 292); 12 feet at McNary Lock and Dam; 24 to 92 feet from McNary Lock and Dam to Kennewick, Wash. (Mile 328); from Kennewick to Canadian border depths are variable due to regulation of reservoirs.	chemical products.
Cumberland River...	Burnside, Ky., Celina, Tenn., Nashville, Tenn., Eddyville, Ky.	693 miles (1,115 km) from junction of Poor and Clover Forks in Harlan County, Ky., to the mouth near Smithland, Ky., on the Ohio River; 55 miles (88.5 km) from Wolf Creek Dam to Burnside, Ky., 194 miles (312 km) are navigable.	9 feet from mouth to Nashville, 194 miles (312 km); 6 feet from Nashville to Niagara Shoals, 137.4 miles (221 km); less than 1 foot, Niagara Shoals to Wolf Creek Dam, 129.3 miles (208 km); 9 feet at Wolf Creek Dam.	Sand, gravel, sulphur, fluorspar, railroad ties, POL and POL products, sugar, molasses, coal, lignite, limestone, crushed rock, iron, steel.
Delaware River...	Wilmington, Del., Philadelphia, Pa., Trenton, N. J.	128.4 miles (207 km) from Trenton to mouth at Delaware Bay (including auxiliary channel east of Burlington Island extending from main channel to East Burlington, 1.4 miles (2.25 km)).	9 feet from Pennsylvania Railroad bridge at Trenton to Trenton Marine Terminal, 1.3 miles (2.09 km); 12 feet from Trenton Marine Terminal to upper end of Newbold Island, 5.5 miles (8.85 km); 23 feet from upper end of Newbold Island to Philadelphia Harbor, 23.7 miles (38.2 km); 27 feet (east side of channel) to 30.8 feet (west side of channel) through Philadelphia Harbor, 10.5 miles (16.9 km); 35 feet from Philadelphia Navy Yard to mouth, 86 miles (138.5 km). Auxiliary channel—18 feet, 1.4 miles (2.25 km).	POL and POL products, glass, furnaceslag, coal, coke, sand, gravel grain and grain products, canned foods, sugar, molasses, soybeans, lumber and lumber products, woodpulp, paper and paper products, clays and earths, gypsum, sulphur, crushed rock, nonmetallic minerals, iron ore and concentrates, iron and steel, chrome, nonferrous ores and metals, coal-tar products, sulphuric acid, industrial chemicals, fertilizer and fertilizer minerals.
Green and Barren Rivers.	Bowling Green, Ky....	Green River—197.8 miles (318 km) from mouth to Mammoth Cave, Ky.; Barren River—30.1 miles (48.5 km) from mouth (Mile 149.5 (241 km), Green River) to Bowling Green.	5.5 feet for entire distance of both rivers—228 miles (367 km).	Bituminous coal and lignite, POL and POL products, limestone, sand, gravel, crushed rock, iron and steel.
Gulf intracoastal	St. Marks, Fla., Carra-	The main route extends	(1) <i>Main route</i> : 12 feet	Sea shells, coal, POL and

Name of waterway	Principal terminals	Critical distances	Controlling depths for specified locations	Typical cargo carried commercially
waterway.	belle, Fla., Panama City, Fla., Pensacola, Fla., Mobile, Ala., New Orleans, La., Lake Charles, La., Port Arthur, Tex., Orange, Tex., Beaumont, Tex., Galveston, Tex., Texas City, Tex., Baytown, Tex., Houston, Tex., Port Lavaca, Tex., Corpus Christi, Tex., Port Isabel, Tex., Brownsville, Tex.	1,116 miles (1,795 km) from St. Marks River to the Mexican border at Brownsville, Tex., with a 55-mile (88.5 km) arm, known as the Plaque Mine-Morgan City Alternate Route, from the Mississippi River at Plaque Mine, La. (113 miles (182 km) above New Orleans) to the main route at Morgan City, La. (100 miles (161 km) west of New Orleans).	from St. Marks River to Pensacola Bay, 245 miles (394 km); 10.5 feet from Pensacola Bay to Mobile Bay, 46 miles (74 km); 11 feet from Mobile Bay to New Orleans, 134 miles (216 km); 12 feet from Mississippi River to Calcasieu River, La., 239 miles (385 km); 17 feet from Calcasieu River to Sabine River, Tex., 27 miles (43.4 km); 11 feet from Sabine River to Galveston, 90 miles (145 km); 10.9 feet from Galveston to Freeport, Tex., 42 miles (67.6 km); 11 feet from Freeport to Port O'Connor, Tex., 79 miles (127 km); 11.6 feet from Port O'Connor to Port Aransas, Tex., 61 miles (98.2 km); 10 feet from Port Aransas to Brownsville, 153 miles (246 km). (2) <i>Plaque Mine-Morgan City route</i> : 9 feet for entire 55 miles (88.5 km).	POL products, iron and steel articles, iron and steel pipe and fittings, sulphur, acids, machinery and machines, clay, pulpwood, chemicals, alcohol, sugar, limestone, logs, salt, grain and grain products, molasses, soybeans, paper and products, lignite, cement, clays and earths, sulphur, sand, gravel, crushed rock, coal-tar products, industrial chemicals.
Houston Ship Channel.	Houston, Tex., Galveston, Tex.	52 miles (83.6 km) from Galveston, across Galveston Bay through the San Jacinto River and Buffalo Bayou, with a light draft extension channel 7 miles (11.3 km) long from the Turning Basin to mouth of White Oak Bayou at Main Street, Houston, and a branch channel in the old channel of Buffalo Bayou behind Brady Island.	36 feet in Houston Ship Channel; 36 feet in Turning Basin; 10 feet in extension to White Oak Bayou; 10 feet in branch behind Brady Island.	Sea shells, grain and grain products, coffee, molasses, cotton, newsprint paper, other paper and products, coal and lignite, POL and POL products, cement, clays and earths, sulphur, sand, gravel, crushed rock, iron and steel, coal-tar products, sulphuric acid, industrial chemicals, fertilizer and fertilizer materials.
Hudson River.....	New York, N. Y., Tarrytown, N. Y., Waterford, N. Y., Poughkeepsie, N. Y., Albany, N. Y., Troy, N. Y.	155 (249 km) miles from New York City (Battery) to Waterford.	40 feet from New York City (Battery) to Spuyten Duyvil Creek, 13 miles (20.9 km); 27 feet from Spuyten Duyvil Creek (Harlem River) to Albany, 131 miles (211 km); 14 feet to Waterford, 11 miles	Copper ore and concentrates, sand and gravel, sugar, coal, lumber, shingles and lath, stone and rock, POL and POL products, coal-tar, copper, syrup and molasses, wood pulp, grain and grain products,

Name of waterway	Principal terminals	Critical distances	Controlling depths for specified locations	Typical cargo carried commercially
			(17.7 km).	automobiles, cement, brick.
Illinois waterway---	Grafton, Ill., Pekin, Ill., Peoria, Ill., Chicago, Ill.	Includes the Illinois River from its mouth on Mississippi River at Grafton to Lockport, Ill., 291 miles (469 km); the Chicago Sanitary and Ship Canal (Chicago Drainage Canal) from Lockport to Damen Avenue, Chicago, 30 miles (48.3 km); the Chicago River (South Branch) from Damen Avenue to Lake Street, Chicago, 4.5 miles (7.24 km); and the Calumet-Sag Channel from its junction with the Chicago Sanitary and Ship Canal to Blue Island, Ill., the Little Calumet and Calumet Rivers to Turning Basin No. 5, 23.8 miles (38.3 km).	9 feet in the Illinois River from its mouth on Mississippi River at Grafton to Lockport, 291 miles (469 km); 16.8 feet in the Chicago Sanitary and Ship Canal from Lockport to Damen Avenue, Chicago, 30 miles (48.3 km); 21 feet in the Chicago River (South Branch) from Damen Avenue to Lake St., Chicago, 4.5 miles (7.24 km); and 9 feet in the Calumet-Sag Channel from its junction with the Chicago Sanitary and Ship Canal to Blue Island, Ill., to Little Calumet and Calumet Rivers to Turning Basin No. 5, 23.8 miles (38.3 km).	Newsprint paper, sulphur, sand, gravel, iron and steel articles, grain and grain products, coal, POL and POL products, phosphate rock, chemicals, sugar, iron and steel scrap, limestone, cement, soybeans, molding sand, molasses, paper and products, lignite, crushed rock, coal-tar products, fertilizer and fertilizer materials.
Kanawha River----	Henderson, W. Va., Point Pleasant, Va.	97 miles (156 km) from junction of New and Gauley Rivers in W. Va. to mouth at Point Pleasant on Ohio River. The navigable portion extends 90 miles (145 km) upstream from mouth.	9 feet for the 90 miles (145 km) above mouth.	Sand and gravel, coal, coke, POL and POL products, sulphur, acids and other chemicals, furnace slag, alcohol, iron and steel, coal-tar products.
Kentucky River----	Beattyville, Ky., Carrollton, Ky.	258.6 miles (416 km) from where it is formed by the confluence of the north and middle forks, about 4 miles (6.44 km) east of Beattyville to mouth at Carrollton.	6 feet for entire length--	Sand, gravel, crushed rock, gasoline and other motor fuels, coal and lignite.
Mississippi River---	Minneapolis, Minn., St. Paul, Minn., St. Louis, Mo., Cairo, Ill., Memphis, Tenn., Vicksburg, Miss., Baton Rouge, La., New Orleans, La.	2,350 miles (3,780 km) from its source in Lake Itasca in central Minnesota to the Gulf of Mexico (513 miles (826 km) from Lake Itasca to Minneapolis, 853 miles (1,373 km) from Minneapolis to mouth of Ohio River, 964 miles (1,550 km) from mouth of Ohio River to Head of Passes, La.,	Commercial navigation above Minneapolis is prohibited by insufficient depths. From Minneapolis to the Gulf (1,837 miles (2,960 km)), the following controlling depths prevail: 9 feet, Minneapolis, to Baton Rouge, 1,588 miles (2,560 km); 35 feet, Baton Rouge to Head	Coffee, sugar, molasses, syrup and honey, rubber, vegetable fibers, aluminum ore, alloys and scrap, grain and grain products, oilseeds (except flaxseed), cotton and cotton linters, sawmill products, sulphur, salt, POL, iron and steel products, fertilizer and fertilizer materials, soda prod-

Name of waterway	Principal terminals	Critical distances	Controlling depths for specified locations	Typical cargo carried commercially
		and 20 miles (32.2 km) from Head of Passes to Gulf of Mexico through Southwest Pass).	of Passes, 229 miles (369 km); and 40 feet from Head of Passes through Southwest Pass to the mouth of the Pass (Gulf of Mexico), 20 miles (32.2 km).	ucts, alcohol, other chemicals, sea shells, bauxite ore, sand and gravel, coal, logs and lumber, iron and steel pipe and fittings, machinery, automobiles, cement and concrete products, brick, bags and bagging, iron and steel scrap.
Missouri River.....	Sioux City, Iowa, Omaha, Neb., Council Bluffs, Iowa, St. Joseph, Mo., Kansas City, Kans., Kansas City, Mo., Independence, Mo., Jefferson City, Mo., St. Louis, Mo.	2,464 miles (3,960 km) from junction of the Jefferson, Madison, and Gallatin Rivers at Three Forks, Mont., to the mouth which enters the Mississippi River 17 miles (27.4 km) above St. Louis. Regular commercial navigation only on the portion improved for navigation from Sioux City to the mouth, 762 miles (1,225 km), consisting of two sections: 376 miles (606 km) from Sioux City to the upper end of Quindaro Bend near Kansas City, Mo., and 386 miles (622 km) from Kansas City to the mouth.	9 feet from mouth to mouth of Big Sioux River at Sioux City, 762 miles (1,225 km); 1½ to 2½ feet from mouth of Big Sioux to Fort Benton, Mont.	Grain and grain products, soybeans, molasses, logs, POL and POL products, sand, gravel, crushed rock, iron and steel, waterway improvement material, metal products and parts, wood posts, poles and piling, machinery and machines.
Monongahela River..	Pittsburgh, Pa., Fairmont, W. Va.	128 miles (206 km) from its formation by the junction of the Tygart and West Fork Rivers (about 1 mile south of Fairmont) to mouth at Pittsburgh.	9 feet for entire length..	Sand and gravel, coal, coke, fluorspar, sulphur, POL and POL products, sulphuric acid, iron and steel articles, pipe and fittings, ferrous scrap, furnace slag, nonmetallic minerals, coal-tar products, industrial chemicals.
New York State Barge Canal.	New York, N. Y., Albany, N. Y., Buffalo, N. Y.	There are 522 miles (840 km) of waterways as follows: (1) Erie Canal from Waterford on the Hudson River to Tonawanda on the Niagara River, 338 miles (544 km); (2) Oswego Canal from Three Rivers Point, N. Y., (on Erie Canal 160 miles (258 km) west of Water-	14 feet in earth cuts, rock cuts, canalized rivers and lakes and in open rivers; 12 feet in locks.	Grain and grain products, POL and POL products, pulpwood, chemicals, fertilizer, paper and paper products, molasses, clay, scrap iron, pig iron and billets, sugar, bituminous materials.

Name of waterway	Principal terminals	Critical distances	Controlling depths for specified locations	Typical cargo carried commercially
		ford) to Oswego on Lake Ontario, 24 miles (38.6 km); (3) Cayuga and Seneca Canals, 90 miles (145 km), connecting with the Erie Canal near the confluence of the Seneca and Clyde Rivers; (4) Champlain Canal from Waterford, on the Hudson River (entrance to Erie Canal) to Whitesall at the south end of Lake Champlain, 60 miles (96.6 km); (5) 10 miles (16.1 km) of connecting channels to canal harbors at Utica, Syracuse, and Rochester.		
Ohio River-----	Pittsburgh, Pa., Cincinnati, O., Louisville, Ky., Evansville, Ind., Cairo, Ill.	981 miles (1,580 km) from Pittsburgh to Cairo.	9 feet for entire distance.	Grain and grain products, coal, railroad ties, coke, sand and gravel, stone and rock, POL and POL products, sulphur, fluorspar, lumber, shingles and lath, sulphuric acid, alcohol, other chemicals, tar, pitch, creosote, iron and steel articles (including pipe and fittings), automobiles, cement, iron and steel scrap, furnace slag.
Sacramento River--	Colusa, Calif., Sacramento, Calif., Benicia, Calif., San Francisco, Calif.	245 miles (394 km) from mouth of river at Colinsville, Calif., to Red Bluff.	20 feet from mouth of river to Cache Slough, 15 miles (24.1 km); 8 feet from Cache Slough to Sacramento, 44 miles (70.8 km); 6 feet from Sacramento to Colusa, 85 miles; 2 feet from Colusa to Chico Landing, 49 miles (79 km); 1.5 feet from Chico Landing to Red Bluff, 52 miles (83.7 km).	Grain and grain products, sugar beets, rock and stone, POL and POL products, canned foods, beet pulp, sand, gravel, fresh vegetables.
San Joaquin River--	Stockton, Calif.-----	127 miles (204 km) from mouth of New York Slough to Hills Ferry. The river consists of two sections: mouth to Stockton (navigable all year), 41 miles (66 km); Stockton Chan-	28 feet from mouth of New York Slough to Mormon Channel, Stockton, Mile 40; 22 feet (with other connecting channels 2 to 9 feet) to Edison Street, Stockton, Mile 41	Canned milk, grain and grain products, fresh and canned vegetables, dried and canned fruits, molasses, POL and POL products, sand, gravel, crushed rock, iron ore, iron and steel,

Name of waterway	Principal terminala	Critical distances	Controlling depth for specified locations	Typical cargo carried commercially
		nel to Hills Ferry (navigable April through June), 86 miles 138.5 km).	(navigable all year); 4 feet from junction with Stockton Channel to Mossdale Bridge, Mile 16; 3 feet to Hills Ferry (Mile 86) (navigable April through June).	industrial chemicals.
Tennessee River----	Knoxville, Tenn., Chattanooga, Tenn., Decatur, Ala., Florence, Ala., Paducah, Ky.	652 miles (1,050 km) from its formation by the junction of the French Broad and Holston Rivers in eastern Tennessee, 4.4 miles (7.08 km) above Knoxville to the mouth at Paducah on the Ohio River.	9 feet from mouth to Knoxville, 647.6 miles (1,040 km).	Grain, coal, coke, clay, POL and POL products, sand, gravel, railroad ties, automobiles, lumber, soybeans, pulpwood, sulphur, limestone, salt, iron and steel, manganese, coal-tar products, chemicals.

ORGANIZATION FOR TRANSPORTATION INLAND WATERWAYS SERVICE

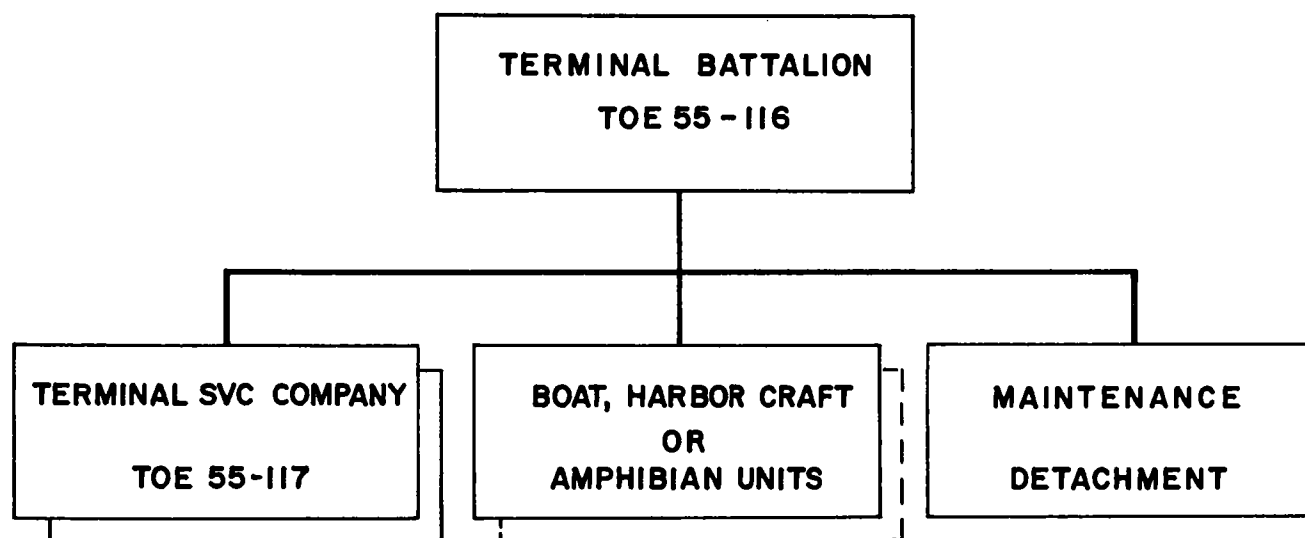


Figure 5.20. Organizational chart, transportation inland waterways service.

5.35 Amphibious Operations

a. Each amphibious landing differs in climatic, hydrographic, and topographic conditions as well as in the military situation. These variable factors make it impractical to develop detailed logistical planning data applicable only to beaches and their capacity to receive troops and cargo; however, certain general planning data can be developed.

b. Beach capacity is the amount of cargo that can be discharged over a given beach length within a stated interval of time. During the initial phases

of an amphibious operation, beach capacity is limited to the beach or beaches over which the assault landing is being made; later, if necessary, overall capacity may be increased by the consolidation of beaches for more efficient operation and for the opening up of sheltered unloading points in rivers or bays. Experience has indicated that, during the assault phase of an operation, cargo can be landed and moved across beaches as follows, using (1) and/or (2) in appropriate combination:

- (1) Average short tons of cargo per day per

mile (1.6 km) of beach—3,000. Average per 1,000 yards (914 meters) of beach—1,700.

- (2) Average number of vehicles and personnel landed simultaneously per day per mile of beach—675 vehicles, 4,725 personnel.

c. To insure successful accomplishment of an amphibious operation, equipment and supplies must be loaded so as to provide maximum support to the landing plan and the scheme of maneuver ashore. The manner in which a ship is loaded determines the order and speed with which equipment and supplies can be unloaded and made available for tactical employment. The composition of amphibious task forces will seldom, if ever, be alike. The methods of loading the ships assigned to transport an amphibious force will normally be determined after careful consideration of the following factors:

- (1) Availability of shipping versus lift requirements for the operation.
- (2) Unloading capability in the objective area versus desired rate of buildup ashore.
- (3) Availability of time versus requirements for detailed and thorough coordination and planning.
- (4) Availability of ship-to-shore means versus requirements for assault craft in the ship-to-shore movement.
- (5) Desired rate of combat force buildup versus base development requirements during assault phase.
- (6) Requirements for special equipment versus availability.
- (7) Conflicts between time requirements and variable weather and climatic conditions.

d. *Types of Military Loading.*

- (1) *Administrative loading.* Administrative loading makes maximum use of troop billeting and cargo spaces. There is no regard for tactical considerations, unit integrity, or priority for unloading. It is used when direct opposition from the enemy will not be encountered upon landing. This method of landing may be employed when personnel and cargo are transported to the objective area in followup shipping or when tactical employment immediately upon landing is not required. Technical details pertaining to administrative loading are contained in TM 55-513.

(2) *Combat loading.*

- (a) Combat loading is used for any operation in which opposition from the enemy is anticipated. Combat loading is designed to insure unit integrity and maximum unloading efficiency of the individual embarkation teams and the landing force as a whole. All other considerations, such as economy of space, must be subordinate. Selected units, with their essential combat equipment and supplies, are loaded in such a manner that they will be available to support the tactical plan upon debarkation. Ships must be loaded to provide for flexibility to meet possible changes in the tactical plan and to facilitate discharge of cargo to meet emergency calls for equipment or supplies. Two objectives of combat loading are—

1. That supplies and equipment loaded aboard ship are so stowed as to be available for unloading and delivery to the assault forces at the time and in the order required to support the tactical situation ashore.
2. That the troops, equipment, and supplies are dispersed throughout the amphibious force shipping in such a manner that the loss or diversion of an embarkation team will not materially affect the tactical integrity of the force embarked in the remaining ships.

- (b) There are three types of combat loading which may be employed, depending upon the mission, organization, types of equipment assigned to the force (including ships), and the planned tactical employment of the force. These are—

1. *Combat unit loading.* Combat unit loading is the loading of an assault troop organization, together with its essential combat equipment and supplies, in a single ship in such a manner that it will be available to support the tactical plan upon debarkation. Combat unit loading provides maximum flexibility to meet possible changes in the tactical plan.

2. *Combat organizational loading.* Combat organizational loading is the loading of a troop organization with its equipment and supplies on the same ship, but without regard to tactical considerations upon debarkation. It permits debarkation of complete units and equipment which will be available for tactical employment after assembly ashore. This method is more economical in ship space than combat unit loading.

3. *Combat spread loading.* Combat spread loading is the loading of troop organizations with their equipment and supplies on two or more ships. This method is commonly used in loading organizations equipped with numerous vehicles and/or large amounts of heavy equipment. Organizations so loaded are available for employment in the landing area upon reassembly of personnel and equipment after landing.

(c) Technical details pertaining to combat loading are contained in FM 60-30.

(3) *Commodity loading.* Commodity loading is a method of loading in which various types of cargo such as ammunition, rations, or boxed vehicles are stowed separately in order that each commodity can be discharged without disturbing other cargo. It is also called block stowage. Portions of compartments are completely filled with items of the particular commodity and are separated from other commodities. Ships are often completely commodity loaded when the cargo consists of class V supplies.

(4) *Selective loading.* Selective loading is a method of loading and stowing equipment and supplies aboard ship in a manner designed to facilitate issue to designated units. Supplies and equipment are stowed so that they can be discharged and delivered on call. Selective loading differs from commodity loading in that all classes of supplies required to support specified units are loaded and stowed so as to be discharged according to planned and/or anticipated requirements.

5.36 Estimating Wheeled Amphibian Requirements

a. Characteristics.

(1) *DUKW.* The combat payload of the 2½-ton, 6 × 6 wheeled landing vehicle (DUKW) ranges from 5,000 to 9,000 pounds, depending on the operating conditions. For planning purposes, the combat payload of the DUKW is 9,000 pounds under ideal operating conditions, 7,500 pounds under favorable conditions, and 5,000 pounds under difficult conditions. Very unfavorable conditions of wind, waves, or obstacles would possibly prevent even a payload of 5,000 pounds or cause operations to cease entirely.

(2) *LARC-5.* The combat payload of the LARC-5 amphibian ranges from 5,000 to 10,000 pounds, depending on the operating conditions. For planning purposes, the combat payload of the LARC-5 is 10,000 pounds under ideal conditions; however, the payload may be reduced to 5,000 pounds, depending on wind, waves, or obstacles. Very unfavorable conditions may cause operations to cease entirely.

(3) *BARC.* The combat payload of the BARC ranges up to 100,000 pounds, depending upon operating conditions. In extreme cases and, if very ideal conditions exist, the BARC may transport 200,000 pounds. The combat payload will vary in accordance with operating conditions, very unfavorable operating conditions could cause operations to cease entirely.

b. *Operating Conditions.* The various factors influencing operating conditions are shown below.

Factors affecting operating conditions	Operating conditions		
	Ideal	Favorable	Difficult
Wind.....	10 mph (16 kmph) or less.	10 to 15 mph (16 to 24 kmph).	Over 15 mph (24 kmph).
Waves.....	Less than 1 ft.	1 to 3 ft.	Over 3 ft.
Beach.....	Gentle slope, hard sand.	Abrupt slope, soft sand.	Construction required. Mud.
Obstacles.....	None.....	Some.....	Prevalent.
Area behind beach.	Good road net.	Trails.....	Cross-country.

c. Estimating Wheel Amphibian Requirements. This requires computation of turnaround time. The accepted average turnaround time factors used for planning purposes are listed below. Whenever possible, data derived from actual operating experience should be substituted for these average factors. When estimating requirements, allowance should be made for the tactical situation and for possible adverse navigation, weather, and road conditions.

	DUKW	LARC-5	BARC
Loading time	8-10 min.	8-10 min.	25 min (heavy vehicles)
Unloading time.	8-10 min.	8-10 min.	5 min (with unloading pit prepared).
Water speed.	5 mph (8 kmph).	10 mph (16 kmph).	8 mph (13 kmph).
Land speed.	10-20 mph (16-32 kmph).	25 mph (40 kmph).	14 mph (23 kmph).

d. Turnaround Time. Turnaround time for wheeled amphibians may be estimated by using the following formula:

$$TT = \frac{W \times 60}{R} + \frac{L \times 60}{R'} + a + b + c$$

where

TT = turnaround time in minutes

*W = water distance (round trip) in miles or kilometers

*L = land distance (round trip) in miles or kilometers

*R = speed on water in miles or kilometers per hour

*R' = speed on land in miles or kilometers per hour

a = loading time in minutes

b = unloading time in minutes (not to exceed loading time)

c = known delays in minutes

e. Continuous Operations. For continuous operations, a planning factor of 75 percent availability of assigned amphibians is assumed because of maintenance requirements. To estimate the number of operational vehicles required for a particular mission, use the formula given below.

$$V = \frac{H \times TT}{X}$$

* If metric system is used, it must be adhered to for W, L, R, and R'.

where

V = number of operational vehicles

H = number of hatches to be worked

TT = turnaround time in minutes

X = most restrictive factor (a, b, or c, whichever is greatest in solution of turnaround time in *d* above.)

5.37 Logistical Over-The-Shore (LOTS) Operations

a. In other than amphibious operations, LOTS operations provide for the movement of cargo and personnel over the shore between ocean transportation and shoreside facilities. Beaches and other more difficult shore lines are used to the extent required. Figure 5.21 shows a typical transportation terminal battalion organization for LOTS operations.

b. LOTS operations include:

- (1) Unloading cargo and personnel from ships into landing craft and/or amphibians.
- (2) Moving cargo and personnel by landing craft and/or amphibians from ships to shore.
- (3) Unloading landing craft at beaches.
- (4) Unloading amphibians at transfer points.
- (5) Moving cargo from landing craft to temporary storage and/or segregation areas or to destination.
- (6) Unloading at storage areas or transfer points.

c. Planning factors for LOTS operations are essentially the same as those for fixed terminal operations. Using ship's gear and stevedore labor provided by the forces offshore, ships normally can discharge cargo into special landing equipment as fast as beaches can receive and clear the loaded landing craft and amphibians. In an amphibious operation, the site selections for subsequent LOTS operations are included in the base development plan: Where LOTS operations are established independently, the selection of possible beach sites is made by the terminal commander in consultation with the proper naval authorities, by an extensive study of maps and hydrographic charts, and by reference to pertinent intelligence surveys, when available. Final determination of the feasibility of operations at possible sites is made by a detailed ground and water reconnaissance. The information may be compiled as shown on the sample reporting format (fig. 5.22). This completed form

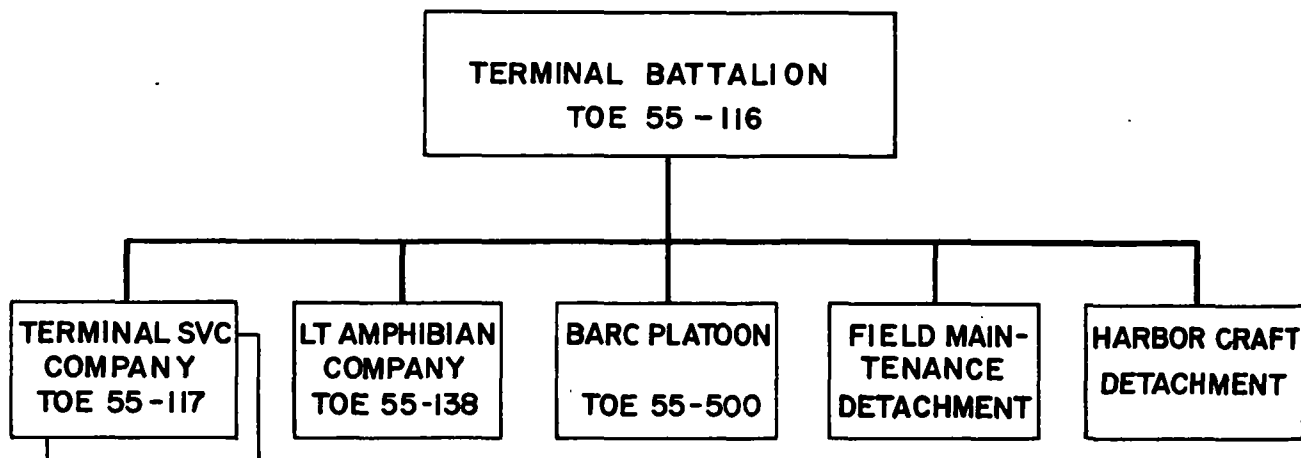


Figure 5.21. A typical transportation terminal battalion organized for a LOTS operation.

is accompanied by a detailed profile sketch of the beach and landing area as shown in figure 5.23.

5.38 Hydrographic Markings for Landing Operations

(fig. 5.24)

a. Hydrographic markings have been developed for use in beach operations in areas not otherwise suitably marked. They are normally installed by transportation personnel or by shore party personnel. They are not related to the aids to navigation maintained by the Coast Guard.

b. During the day, a pennant with alternate red and black vertical stripes is fastened to a buoy or stake to show the locations of rocks, shoals, or submerged obstacles. This pennant is replaced at night by a white light over a red light, both blinking.

c. Hydrographic markings for channels consist of the following:

- (1) A red pennant by day and a steady red light at night mark the starboard side of the channel for boats coming from seaward.
- (2) A black pennant by day and a blinking white light by night mark the port side.
- (3) A black and white vertically striped

pennant by day and a blinking green light at night mark a fairway.

- (4) Two blinking green lights, one over the other, indicate a range (TM 55-508).

5.39 Beach and Debarkation Point Markers (fig. 5.25)

a. During the process of beach organization, debarkation points for various categories of supply and equipment are selected on each beach where they best support the tactical plan. Beach markers and debarkation point markers are erected by shore party personnel as soon as possible after the initial assault of an amphibious landing has been made.

b. Beach markers are large pieces of cloth secured to supports and held aloft. Beaches under attack are given a color designation, such as Red Beach, Green Beach, etc., and beach markers are constructed in corresponding colors. The center of a beach is marked by a large square of cloth with the color facing seaward. The left flank of the beach, as seen from the sea, is denoted by a horizontal rectangle of the same color; the right flank is marked by a vertical rectangle, also of the same color. Debarkation-point markers are set up to indicate to the craft crews where the various types of cargo are to be landed.

CHARACTERISTICS OF BEACHES AND LANDING AREAS - TRANSPORTATION INTELLIGENCE						NAME OF FACILITY Marlin Area Beaches		PREPARED BY J. B. MORTON, Major, TC		HEADQUARTERS 35th Trans Intel Team (Collection)		KEY NA - Not Applicable		PAGE NUMBER 3	NUMBER OF PAGES 7
BEACH NUMBER AND LOCATION	LENGTH OF BEACH		WIDTH OF BEACH		BEACH GRADIENTS		APPROACH (Bottom gradient, water depths, winds, reefs, etc.)	SURF AND TIDAL RANGE	MATERIAL AND FIRMNESS	DESCRIPTION OF TERRAIN IMMEDIATELY BEHIND BEACH	EXITS AND COMMUNICATIONS INLAND				
	OVERALL LENGTH	USABLE LENGTH	LOW WATER	HIGH WATER	LOW WATER	HIGH WATER									
No. 22. Centered 600 yd NE of Leander and 8.6 mi SW of Ocean View at 11°12' N, 22°22' E	2,000 yd	All usable	Aprx 30 yd	Aprx 20 yd	Aprx 1 in 30	1 in 20	Near shore bottom slopes flat; 2.4- to 4.6-ft depths 30 yd offshore; 6.8-ft depth 400 yd SW end 700 yd off SE end of beach. Approach from NW and bay generally clear over shoal depth with some rocky patches. Approach flanked on SE by small islands, reefs, and rocks, which extend for about 2 miles NW of Leghorn. Bottom mud and sand; weedy close to shore.	Surf rough with prevailing northerly winds; tidal range 1.0 ft, spring tides.	Sand: soft and fine; firm only in wetted area.	Soft, sandy back-shore generally unsuitable for wheeled vehicles, backed by a sea wall and 900 yd of sand hummocks 4.6 ft high, covered with brush; all on a flat, open plain.	Across 900 yd sandy terrain by narrow one-lane road to a primary road and railroad leading to Leander.				
No. 12 Seaview to Lakeland; centered 22°26' N, 33°36' E. On sandspit terminated on W by entrance channel into Lake Yerhe	5.2 miles	4.6 miles usable	Aprx 85 yd	Aprx 50 yd	Aprx 1 in 50	1 in 50	Near shore bottom slopes mild to flat; 6-ft depth generally 160 yd off beach except at W end where 400 yd offshore; 18-ft depth 2.0 miles offshore; approach clear, over gradually shoaling sand and mud bottom; 30-ft anchorage 4.0 mile offshore E of breakwater. Bottom hard sand.	Surf rough with onshore winds; tidal range aprx 1.6 ft, spring tides.	Sand and sandstone--believed to be firm.	Low sand dunes backed by hilly sandy terrain as high as 40 ft and completely covered with vegetation; terrain directly back of beach flanked on E and W by vast salt marshes.	A primary road parallels the shore about 2.0 miles inland; railroad parallels the shore 3 miles from beach. Cross-country exit across dune area to network of minor roads or trails connecting with secondary road, connecting with primary road at Hilldale.				
REMARKS															
NOTE: Beach lengths and distances along the coast and inland are expressed in statute miles, distances across water are expressed in nautical miles except when referring to beach locations.							DATE 27 June 1961	TYPED NAME AND GRADE B. C. DALTON, Lt Colonel, TC, Commanding		SIGNATURE <i>B. C. Dalton</i>					

Figure 5.22. Characteristics of beaches and landing areas.

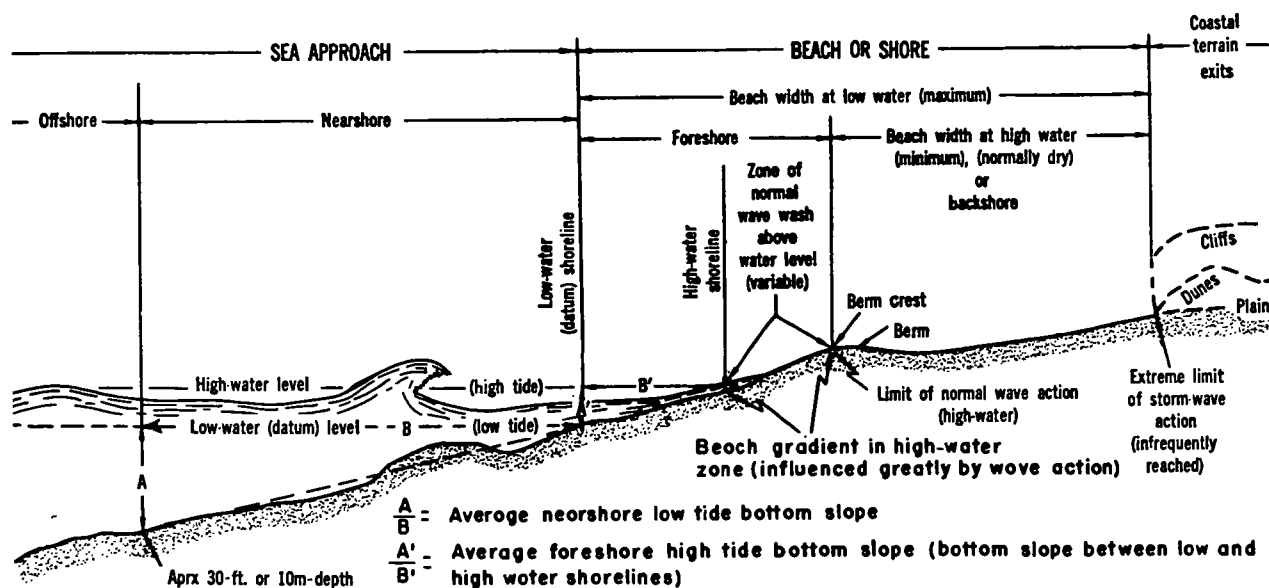


Figure 5.23. Beach profile diagram.

LEFT SIDE FROM SEAWARD	OBSTRUCTION	FAIRWAY	RIGHT SIDE FROM SEAWARD	RANGE LIGHTS
DAY (FLAGS)				
NIGHT (LIGHTS)				
 BLINKING	 BLINKING	 BLINKING	 STEADY	 BLINKING

Figure 5.24. Hydrographic markings for landing operations.

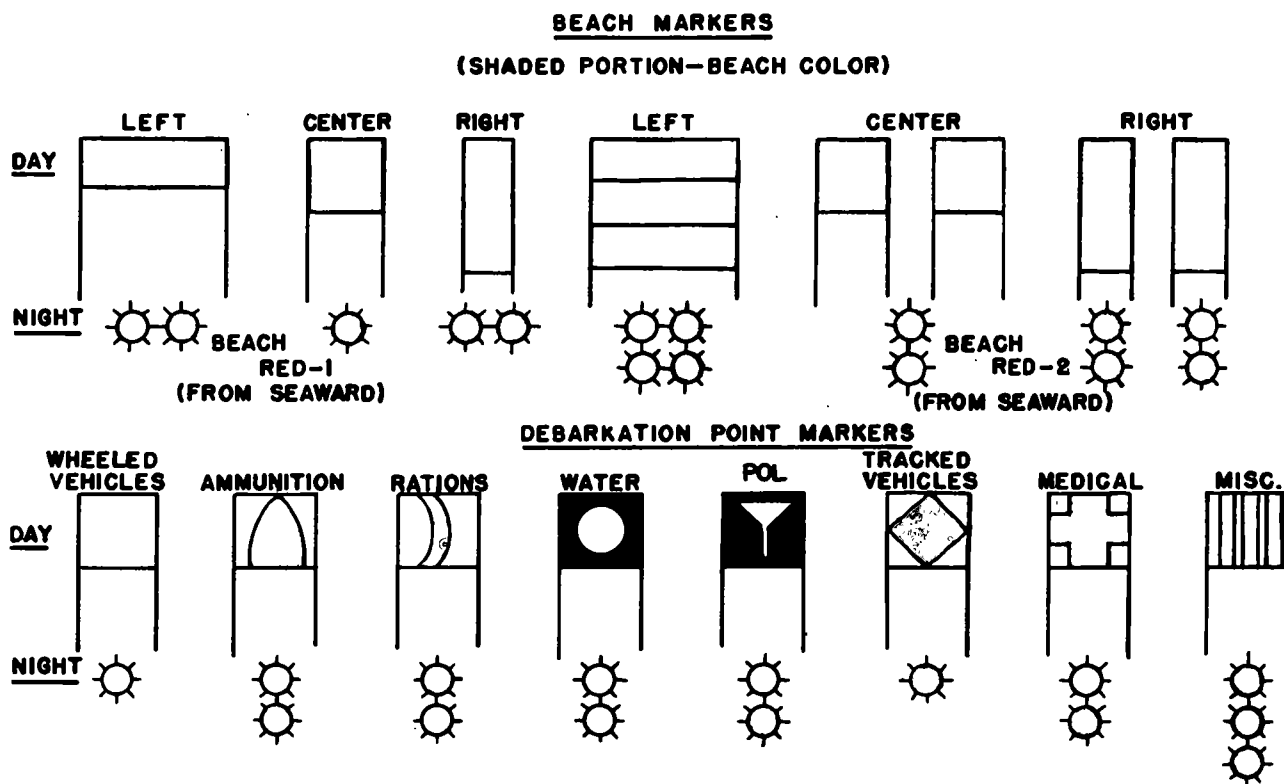


Figure 5.25. Beach and debarkation point markers.

Section IV. HOISTING AND CONVEYING DATA

5.40 Strength of Rope

a. The safe working capacity in tons for any size of manila rope is approximately equal to the square of the diameter in inches if a safety factor of 4 is used. In exceptional cases the rated safe working load may be exceeded, but under no circumstances should rope be loaded to more than twice its safe working capacity.

b. A rope sling over a hook is reduced in strength by approximately 30 percent. Sharp bends over corners further reduce the strength of the rope. Sand or grit between the fibers or exposure to heat will destroy the fibers and rapidly reduce the strength of the rope.

5.41 Properties of Manila Rope

The following table is for new manila rope used under favorable conditions. As rope ages or deteriorates, progressively reduce safe loads to one-half of values given. To determine the safe working load of sisal rope, deduct one-fifth from the safe working load of manila rope of the same size.

Nominal diameter (inches)	Circumference (inches)	Weight per 100 feet (pounds)	Breaking strength (pounds)	Safe load (pounds)*
$\frac{1}{4}$	$\frac{3}{4}$	2.0	600	150
$\frac{3}{8}$	$1\frac{1}{8}$	4.10	1,350	335
$\frac{1}{2}$	$1\frac{1}{2}$	7.50	2,650	660
$\frac{5}{8}$	2	13.3	4,400	1,100
$\frac{3}{4}$	$2\frac{1}{4}$	16.7	5,400	1,350
$\frac{7}{8}$	$2\frac{3}{4}$	22.5	7,700	1,920
1	3	27.0	9,000	2,250
$1\frac{1}{8}$	$3\frac{1}{2}$	36.0	12,000	3,000
$1\frac{1}{4}$	$3\frac{3}{4}$	41.8	13,500	3,380
$1\frac{1}{2}$	$4\frac{1}{2}$	60.0	18,500	4,620
$1\frac{3}{4}$	$5\frac{1}{2}$	89.5	26,500	6,625
2	6	108.0	31,000	7,750
$2\frac{1}{2}$	$7\frac{1}{2}$	167.0	46,500	11,620
3	9	242.0	64,000	16,000

* Safety factor of 4.

5.42 Knots, Bends, and Hitches

Knots, bends, and hitches used to work lines aboard a vessel and in terminal operations are shown in figure 5.26.

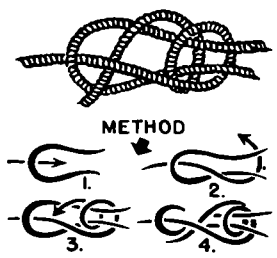
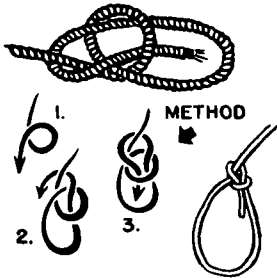
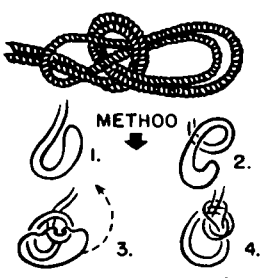
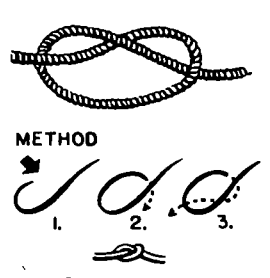
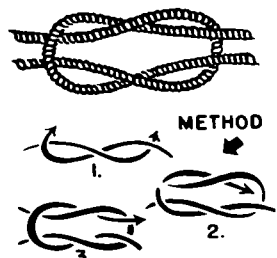
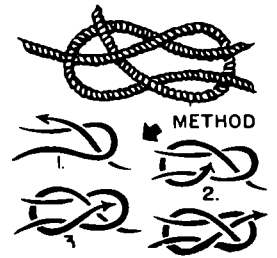
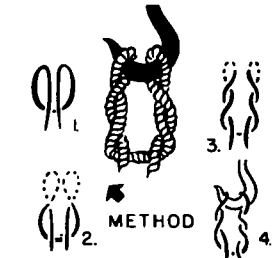
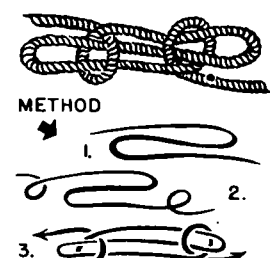
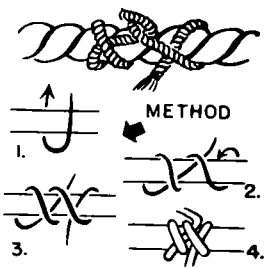
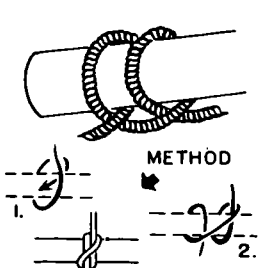
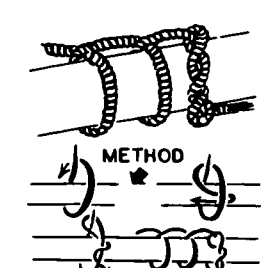
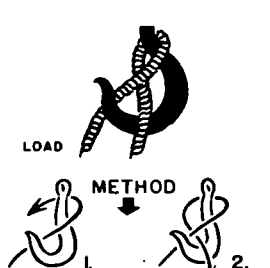
 DOUBLE-SHEET BEND To join two wet ropes of different diameters.	 BOWLINE To form a loop of any desired size that will not slip.	 BOWLINE ON A BIGHT To form a loop with a double purchase. To form a loop in a rope when the ends are not available.	 OVERHAND KNOT To prevent the end of a rope from unravelling. To prevent the end from passing back through the sheave of a block.
 SQUARE KNOT To join ends of the same rope. To tie together two ropes of equal diameter.	 SINGLE-SHEET BEND To join two ropes of different diameters.	 CAT'S PAW To obtain a double bearing surface on a hook.	 SHEEPSHANK To shorten a rope when ends are not available. To bypass a weak section of a rope when ends are not available.
 ROLLING HITCH To form a hitch which will hold on a spar or rope yet will slide readily upon a slight adjustment.	 GLOVE HITCH To fasten guy lines to anchorages and spars.	 TIMBER HITCH WITH TWO HALF HITCHES To haul a log, spar, gun tube, or any long cylindrical object with the pull line parallel to the object drawn.	 BLACKWALL HITCH To secure a rope to a hook rapidly.

Figure 5.26. Knots, bends, and hitches.

5.43 Wire Rope

Wire rope varies considerably in construction characteristics and in the quality of steel used. In terminal operations, the most common rope constructions are 6 strands of 7 wires each and 6 strands of 19 wires each. The 6 × 7 wire rope being stiffer, is suitable for guys, stays, and other stabilized uses where the rope does not bend around sheaves or drums. The more pliable 6 × 19 wire rope is suitable for hoisting use involving sheaves and drums. For a given rope size and type of steel (plow steel is most commonly used) the strength of wire rope varies only slightly with the strand construction and number of strands. The maximum allowable working load is the breaking strength divided by the appropriate safety factor. Characteristics of 6 × 19 wire rope are as follows:

Diameter (inches)	Approximate weight per 100 feet (pounds)	Breaking strength (short tons)		
		Mild plow steel	Plow steel	Improved plow steel
1/4	10	2.07	2.39	2.74
5/16	16	3.31	3.82	4.23
3/8	23	4.6	5.3	6.1
7/16	31	6.2	7.1	8.9
1/2	40	8.5	9.4	10.8
9/16	51	10.8	12.0	13.7
5/8	63	12.6	14.4	16.6
3/4	90	18.0	20.6	23.7
7/8	123	24.3	28.0	32.2
1	160	31.6	36.5	42.0
1 1/8	203	39.8	46.0	53.0
1 1/4	250	48.8	56.5	65.0
1 3/8	304	59.4	68.7	80.0
1 1/2	360	69.6	80.5	92.5
1 5/8	424	81.9	94.9	104.5
1 3/4	492	95.0	110.0	124.5
2	640	123.6	143.2	155.5
2 1/4	812	156.9	181.5	207.0
2 1/2	1,000	193.4	223.3	254.5
2 3/4	1,216	235.0	271.0	306.0

5.44 Wire Rope Safety Factors

Type of service	Minimum safety factor	Type of service	Minimum safety factor
Track cables.....	3.2	Haulage ropes.....	6.0
Guys.....	3.5	Derricks.....	6.0
Miscellaneous hoisting equipment.....	5.0	Small electric and air hoists.....	7.0

5.45 Properties of Chains

Normal size (diameter of stock in inches)	Approximate weight per 100 ft (lbs)	Safe working load*			
		Common iron (pounds)	High-grade iron (pounds)	Soft steel (pounds)	Special steel (pounds)
1/4	73	-----	1,530	1,800	2,620
5/16	110	-----	2,160	2,540	3,700
3/8	160	2,700	2,980	3,500	5,100
7/16	210	3,460	3,800	5,000	6,600
1/2	280	4,500	4,960	6,000	8,200
9/16	340	5,820	6,400	7,770	10,620
5/8	430	6,940	7,620	9,000	11,500
3/4	630	10,140	11,160	12,000	16,200
7/8	840	14,000	15,400	20,250	28,660
1	1,100	18,600	20,460	24,900	36,400
1 1/8	1,300	23,200	25,600	31,100	45,400
1 1/4	1,580	28,600	31,500	38,300	55,900
1 3/8	2,120	34,600	38,100	46,300	67,600
1 1/2	2,520	41,200	45,400	55,200	80,400
1 5/8	2,940	48,000	52,900	64,300	93,600
1 3/4	3,360	55,300	61,000	74,200	108,000
1 7/8	3,880	63,100	69,600	84,700	123,200
2	4,400	71,300	78,700	95,800	139,400

* If the type of iron in a chain is unknown, a safe working load (in short tons) is figured by multiplying 8 by the square of the diameter (in inches) of the metal stock on one side of any link. This applies only to chains made of ferrous metals.

5.46 Safe Working Loads of Slings

a. The stress or tension in each leg of a sling depends on the number of legs, the angles of the sling legs, and the total load. The total weight lifted is divided among the supporting sling legs and acts straight downward. As the horizontal angle of the leg decreases, the tension in the leg increases, since this tension is a function of the sine of the horizontal angle. Ordinarily, the hoisting line and the sling legs are of the same material and the same size, but this is not always the case. Sometimes the sling legs are of smaller material than the hoisting line, particularly when horizontal angles are large. The strength of the hoisting line determines the maximum lifting power of the combination. Since, preferably, the tension in each sling leg is less than or is equal to the tension in the hoisting line, the tension in each leg of a sling should be known. This can be computed by using the following formulas:

$$T = \frac{WL}{NV}$$

or

$$T = \frac{W}{N \times \text{sine } A}$$

where

T = tension in the leg, in pounds (depending upon the horizontal angle of the leg, this tension could be considerably more than the total load being lifted)

W = weight lifted, in pounds

L = length of the leg, in inches

N = number of slings legs

V = vertical distance from the sling platform or sling bar to the hook, in inches

A = angle leg makes with the horizontal

b. The safe working loads of rope, chain, and wire-rope sling combinations under various lift conditions are listed in *c* through *e* below. Due to the inherent loss of strength in the sling combinations (ties, splices, bends, etc.), appropriate reductions in the "straight pull" safe working loads have been made. The angles in each table are measured from the horizontal. In the unusual situations where triple slings are encountered, multiply quantities shown for double slings by one and a half.

c. *Manila-Rope Slings.* (Standard, three-strand manila-rope sling with a splice in each end.)

Size		Single sling	Double sling			Quadruple sling		
Circumference (inches)	Diameter (inches)	Vertical lift (pounds)	60° angle (pounds)	45° angle (pounds)	30° angle (pounds)	60° angle (pounds)	45° angle (pounds)	30° angle (pounds)
$\frac{3}{4}$	$\frac{1}{4}$	108	187	153	108	374	306	216
$1\frac{1}{8}$	$\frac{3}{8}$	241	418	341	241	836	683	482
$1\frac{1}{2}$	$\frac{1}{2}$	475	822	672	475	1,645	1,345	950
2	$\frac{5}{8}$	791	1,370	1,119	791	2,740	2,238	1,582
$2\frac{1}{4}$	$\frac{3}{4}$	970	1,680	1,375	970	3,360	2,750	1,940
$2\frac{3}{4}$	$\frac{7}{8}$	1,382	2,395	1,945	1,382	4,790	3,890	2,764
2	1	1,620	2,805	2,290	1,620	5,610	4,580	3,240
$3\frac{1}{2}$	$1\frac{1}{8}$	2,160	3,740	3,060	2,160	7,480	6,120	4,320
$3\frac{3}{4}$	$1\frac{1}{4}$	2,430	4,205	3,437	2,430	8,410	6,875	4,860
$4\frac{1}{2}$	$1\frac{1}{2}$	3,330	5,770	4,715	3,330	11,540	9,430	6,660
$5\frac{1}{2}$	$1\frac{3}{4}$	4,770	8,250	6,750	4,770	16,500	13,500	9,540
6	2	5,580	9,670	7,900	5,580	19,340	15,800	11,160
$7\frac{1}{2}$	$2\frac{1}{2}$	8,366	14,500	11,850	8,366	29,000	23,700	16,732
9	3	11,520	19,950	16,300	11,520	39,900	32,600	23,040

d. *Chain Slings.* (New wrought-iron chains.)

Link stock diameter (inches)	Single sling	Double sling			Quadruple sling		
	Vertical lift (pounds)	60° angle (pounds)	45° angle (pounds)	30° angle (pounds)	60° angle (pounds)	45° angle (pounds)	40° angle (pounds)
$\frac{3}{8}$	2,510	4,350	3,555	2,510	8,700	7,110	5,020
$\frac{7}{16}$	3,220	5,575	4,560	3,220	11,150	9,120	6,440
$\frac{1}{2}$	4,180	7,250	5,915	4,180	14,500	11,830	8,360
$\frac{9}{16}$	5,420	9,375	7,670	5,420	18,750	15,340	10,840
$\frac{5}{8}$	6,460	11,175	9,150	6,460	22,350	18,300	12,920
$\frac{3}{4}$	9,160	15,850	12,950	9,160	31,700	25,900	18,320
$\frac{7}{8}$	13,020	22,550	18,410	13,020	45,100	36,820	26,040
1	17,300	29,900	24,450	17,300	59,800	48,900	34,600
$1\frac{1}{8}$	21,550	37,350	30,550	21,550	74,700	61,100	43,100
$1\frac{1}{4}$	26,600	36,050	37,600	26,600	92,100	75,200	53,200
$1\frac{3}{8}$	32,200	55,750	45,600	32,200	111,500	91,200	64,400
$1\frac{1}{2}$	38,300	66,400	54,250	38,300	132,800	108,500	76,600
$1\frac{5}{8}$	44,600	77,200	63,050	44,600	154,400	126,100	89,200
$1\frac{3}{4}$	51,300	88,750	72,500	51,300	177,500	145,000	102,600
$1\frac{7}{8}$	58,700	101,500	83,000	58,700	203,000	166,000	117,400
2	66,200	114,500	93,500	66,200	229,000	187,000	132,400

e. *Wire Rope Slings.* (New improved plow-steel wire rope.)

Diameter (inches)	Single sling	Double sling			Quadruple sling		
	Vertical lift (pounds)	60° angle (pounds)	45° angle (pounds)	30° angle (pounds)	60° angle (pounds)	45° angle (pounds)	30° angle (pounds)
1/4	1,096	1,899	1,552	1,096	3,798	3,105	2,192
5/16	1,690	2,925	2,390	1,690	5,850	4,780	3,380
3/8	2,460	4,260	3,485	2,460	8,520	6,970	4,920
7/16	3,560	6,170	5,040	3,560	12,340	10,080	7,120
1/2	4,320	7,475	6,105	4,320	14,950	12,210	8,640
9/16	5,460	9,450	7,725	5,460	18,900	15,450	10,920
5/8	6,650	11,500	9,400	6,650	23,000	18,800	13,300
3/4	9,480	16,400	13,400	9,480	32,800	26,800	18,960
7/8	12,900	22,350	18,250	12,900	44,700	36,500	25,800
1	16,800	29,100	23,750	16,800	58,200	47,500	33,600
1 1/8	21,200	36,700	30,000	21,200	73,400	60,000	42,400
1 1/4	26,000	45,000	36,800	26,000	90,000	73,600	52,000
1 3/8	32,000	55,400	45,250	32,000	110,800	90,500	64,000
1 1/2	37,000	64,000	52,340	37,000	128,000	104,700	74,000
1 5/8	41,800	72,400	59,200	41,800	144,800	118,400	83,600
1 3/4	49,800	86,250	70,500	49,800	172,500	141,000	99,600
2	62,300	107,600	88,050	62,300	215,200	176,100	124,600
2 1/4	82,900	143,500	117,400	82,900	287,000	234,800	165,800
2 1/2	101,800	176,250	144,000	101,800	352,500	288,000	203,600
2 3/4	122,500	212,000	173,500	122,500	424,000	347,000	245,000

5.47 Safe Loads on Hooks.

The data below are keyed to figure 5.27.

Diameter of metal A (inches)	Inside diameter of eye B (inches)	Width of opening C (inches)	Length of hook D (inches)	Safe load on hook (pounds)
11/16	7/8	1 1/16	4 15/16	1,200
3/4	1	1 1/8	5 13/32	1,400
7/8	1 1/8	1 1/4	6 1/4	2,400
1	1 1/4	1 3/8	6 7/8	3,400
1 1/8	1 3/8	1 1/2	7 5/8	4,200
1 1/4	1 1/2	1 11/16	8 19/32	5,000
1 3/8	1 5/8	1 7/8	9 1/2	6,000
1 1/2	1 3/4	2 1/16	10 11/32	8,000
1 5/8	2	2 1/4	11 27/32	9,400
1 3/4	2 3/8	2 1/2	13 3/32	11,000
2 1/4	2 3/4	3	14 13/16	13,600
2 3/8	3 1/8	3 3/8	16 1/2	17,000
3	3 1/2	4	19 3/4	24,000

Rope diameter (inches)	Minimum groove diameter in inches for given rope constructions*			
	6 × 7	6 × 19	6 × 37	8 × 19
1	42	34	18	26
1 1/8	47 1/4	38 1/4	20 1/4	29 1/4
1 1/4	52 1/2	42 1/2	22 1/2	32 1/2
1 1/2	63	51	27	39

* Rope construction is in strands times wires per strand.

5.48 Minimum Groove Diameter of Sheaves and Drums

Rope diameter (inches)	Minimum groove diameter in inches for given rope constructions*			
	6 × 7	6 × 19	6 × 37	8 × 19
1/4	10 1/2	8 1/2	-----	6 1/2
3/8	15 3/4	12 3/4	6 3/4	9 3/4
1/2	21	17	9	13
5/8	26 1/4	21 1/4	11 1/4	16 1/4
3/4	31 1/2	25 1/2	13 1/2	19 1/2
7/8	36 3/4	29 3/4	15 3/4	22 3/4

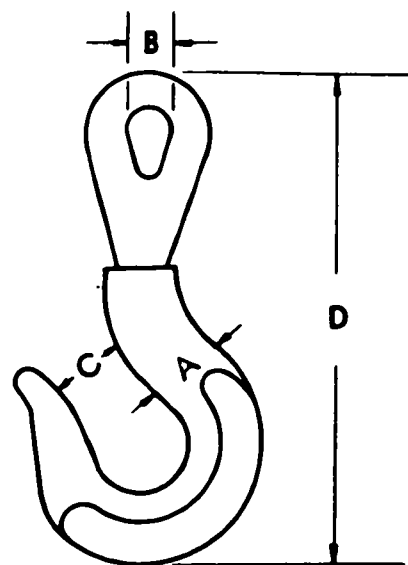


Figure 5.27. Cargo hook: critical dimensions

5.49 Blocks and Tackle

a. Blocks and tackle consist of sheaves (blocks) and ropes arranged so as to obtain a mechanical advantage. As shown in figure 5.28, the force P applied to the lifting end of the rope is much smaller than would be required to lift weight W without using block and tackle. P represents the pull on the rope that supports an equal part of the weight acting on the whole tackle.

b. Figure 5.29 depicts sample block and tackle riggings for manila and wire rope. Single-, double- and triple-sheave blocks are shown. Numbers on the illustration indicate the number of lines in the rigging.

- (1) *Block and tackle rigging for manila rope.* Permissible rope diameters are for new rope used under favorable conditions and normally with a safety factor of 4. As rope ages or deteriorates, the safety factor must be increased progressively to 8 when determining the size rope to be used. The smallest permissible rope diameter is given in inches and the lead line pull in pounds.

	Total number of sheaves in blocks					Load to be lifted (in tons)
	2 single	1 single, 1 double	2 double	1 double, 1 triple	2 triple	
Rope	1/2	7/16	3/8	3/8	3/8	1/2
Pull	540	380	280	220	185	
Rope	3/4	5/8	1/2	1/2	1/2	1
Pull	1,100	740	560	445	370	
Rope	7/8	3/4	5/8	5/8	1/2	1 1/2
Pull	1,600	1,100	840	670	560	
Rope	1 1/8	1/8	3/4	5/8	5/8	2
Pull	2,200	1,500	1,120	890	745	
Rope	5/16	1 1/8	1	7/8	3/4	3
Pull	3,300	2,220	1,670	1,330	1,110	
Rope	1 1/2	1 1/4	1 1/8	1	1	4
Pull	4,440	2,960	2,220	1,780	1,480	
Rope	-----	1 1/2	1 5/16	1 1/4	1 1/8	6
Pull	-----	4,450	3,330	2,670	2,220	
Rope	-----	-----	1 5/8	1 1/2	1 5/16	8
Pull	-----	-----	4,450	3,560	2,970	

- (2) *Block-and-tackle rigging for plow steel wire rope.* Permissible rope diameters are for rope in good condition (not excessively worn or frayed). A safety factor of 6 is used. The smallest permissible rope diameter is given in inches and the lead line pull in pounds.

	Total number of sheaves in blocks					Load to be lifted (in tons)
	2 single	1 single, 1 double	2 double	1 double, 1 triple	2 triple	
Rope	3/8	3/8	3/8	3/8	3/8	1
Pull	1,100	740	560	445	370	
Rope	1/2	3/8	3/8	3/8	3/8	2
Pull	2,200	1,480	1,100	880	740	
Rope	5/8	1/2	1/2	3/8	3/8	4
Pull	4,400	2,960	2,200	1,780	1,480	
Rope	3/4	5/8	5/8	1/2	1/2	6
Pull	6,600	4,440	3,400	2,660	2,220	
Rope	7/8	3/4	5/8	5/8	5/8	8
Pull	8,900	5,940	4,450	3,560	2,970	
Rope	1	7/8	3/4	5/8	5/8	10
Pull	11,100	7,410	5,550	4,450	3,710	
Rope	1 1/8	1	7/8	3/4	3/4	15
Pull	16,640	11,100	8,350	6,670	5,550	
Rope	1 1/2	1 1/8	1	7/8	7/8	20
Pull	22,200	14,800	11,100	8,900	7,400	

c. *Recommended Sizes of Tackle Blocks.* The largest diameter of sheave for a given size of rope is preferred, when available, except that for 6 × 37 (6 strands, each with 37 wires) wire rope, the smallest diameter of sheave indicated below is suitable.

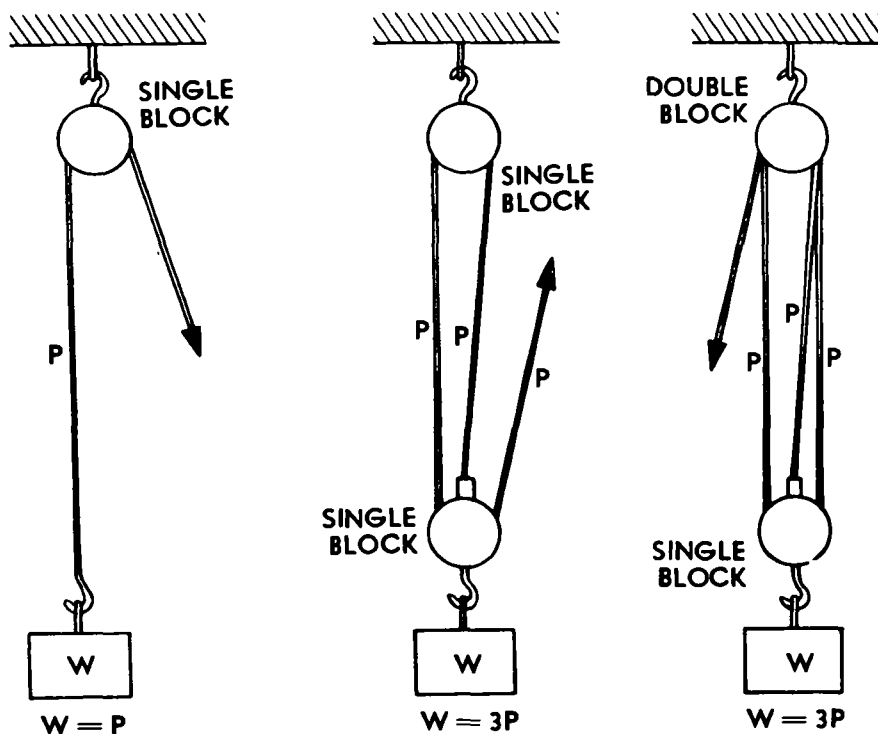
Wire rope		Manila rope	
Rope diameter (inches)	Outside diameter of sheave (inches)	Rope diameter (inches)	Length of block (inches)
3/8	6 to 8	1/2	4
1/2	8 to 10	5/8	6
5/8	10 to 12	3/4	6 to 7
3/4	12 to 16	7/8	7 to 8
7/8	14 to 18	1	8 to 10
1	14 to 20	1 1/8	8 to 10
		1 1/4	10 to 12
		1 1/2	12 to 14
		1 3/4	14 to 16

d. *Effect of Block-and-Tackle Rigging on Strength of Wire Rope.* Wire rope loses some of its tensile strength when it is passed around sheaves or drums. The amount of this loss depends upon variable factors, such as type and size of rope and diameter of sheave or drum. The table below shows percentage of reduction in the rated tensile strength for 6 × 7 and 6 × 19 plow-steel wire rope when passed around sheaves or drums of various diameters. Obviously, the 6 × 19 rope is more adaptable for this use (par. 5.42), for the percentage of tensile-strength loss for a given size of 6 × 19 rope is much less than for the 6 × 7 rope. It should also be noted from the table that the percentage of tensile-strength loss varies inversely with the size of the sheave or drum.

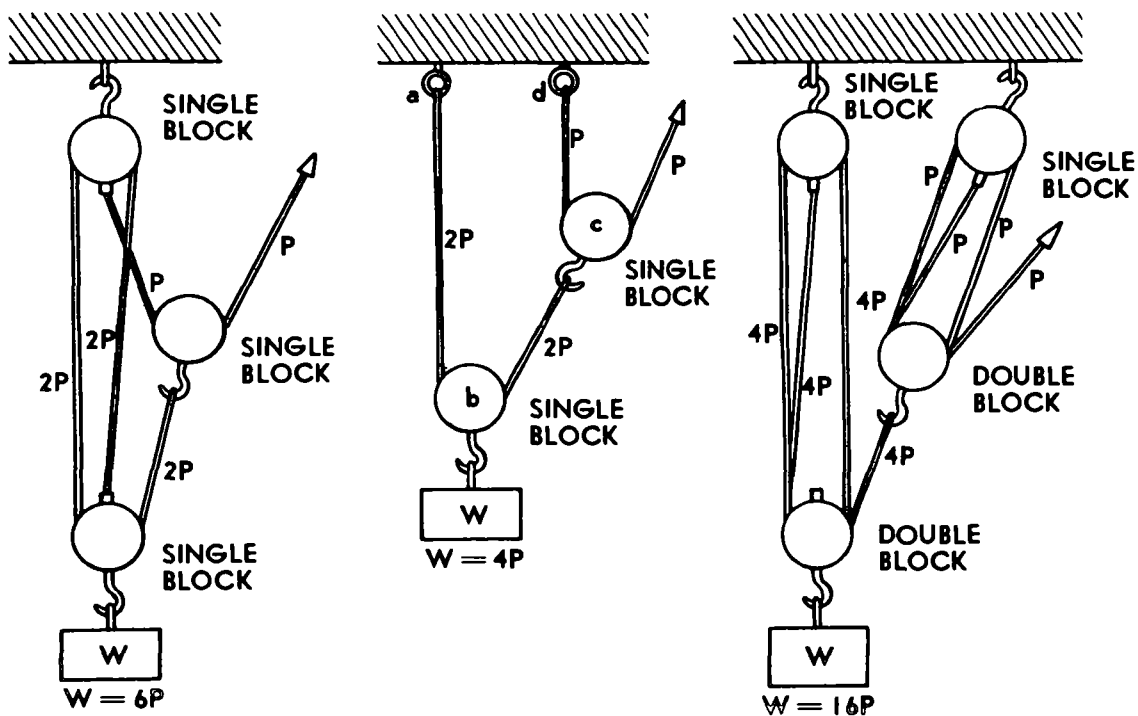
Rope diameter (in.)	6 strands, each with 7 wires									6 strands, each with 19 wires								
	Sheave or drum diameter (ft)									Sheave or drum diameter (ft)								
	1	2	3	4	6	8	10	15	20	1	2	3	4	6	8	10	15	20
1/4										6.4	3.4	2.3	1.9	1.1				
5/16		4.5	3.0	2.2	1.5	1.1	.9	.6		8.9	4.5	3.2	2.4	1.6				
3/8		8.0	5.2	4.1	2.7	2.0	1.6	.9		10.4	5.2	3.5	2.6	1.7				
7/16		10.0	6.8	5.1	3.4	2.5	2.0	1.4		11.8	5.9	3.8	3.0	1.9	1.5			
1/2		13.7	9.1	6.9	4.6	3.4	2.7	1.9		13.6	6.8	4.6	3.4	2.3	1.7	1.4		
5/8		14.0	9.2	7.0	4.6	3.5	2.8	1.9		15.6	7.8	5.4	3.9	2.7	2.0	1.6		
3/4		16.3	11.0	8.2	5.5	4.1	3.3	2.2		17.6	8.8	5.9	4.4	3.0	2.2	1.7		
7/8		17.2	11.5	8.6	5.8	4.3	3.4	2.3		20.6	10.3	7.0	5.1	3.5	2.6	2.0		
1		20.5	13.7	10.3	6.8	5.1	4.1	2.7		25.9	13.0	8.7	6.5	4.3	3.2	2.6	1.7	1.3
1 1/8			16.7	12.5	8.3	6.3	5.0	3.3			14.8	9.8	7.4	4.9	3.7	3.0	2.0	1.5
1 1/4			19.7	14.7	9.8	7.4	5.9	3.9			16.9	11.3	8.4	5.7	4.2	3.4	2.3	1.7
1 1/2				16.7	11.2	8.3	6.7	4.5			18.8	12.6	9.4	6.3	4.7	3.8	2.5	1.9
1 3/8				18.2	12.2	9.1	7.3	4.9			20.2	13.5	10.1	6.7	5.1	4.0	2.7	2.0
1 3/4				20.2	13.5	10.1	8.1	5.4				15.3	11.5	7.7	5.8	4.6	3.1	2.3
1 7/8				23.1	15.4	11.6	9.2	6.2				17.0	12.8	8.5	6.4	5.1	3.4	2.6
2												17.9	13.4	8.9	6.7	5.4	3.6	2.7
2 1/4													16.0	10.7	8.0	6.4	4.3	3.2
2 1/2													17.1	11.4	8.6	6.9	4.6	3.4
2 3/4														12.7	9.6	7.6	5.1	3.8
3														14.1	10.6	8.5	5.6	4.2

5.50 Cubic Capacities, Weights, and Dimensions of Various Grab Buckets (Clamshells)

Capacity (cu yd)	Weight (lb)	Overall length of opened bucket (in.)	Overall length of closed bucket (in.)	Width of bucket (in.)
<i>General-purpose bucket with ore bowl</i>				
1/2	1,700	72	48	36
3/4	2,700	85	60	40
1	3,200	99	67	40
1 1/4	3,400	99	67	47
1 1/2	4,400	108	74	50
1 3/8	4,600	108	74	54
2	5,500	108	76	62
2 1/2	7,400	120	84	63
3	8,000	120	84	74
4	12,000	141	104	74
<i>General-purpose bucket</i>				
1/2	1,500	70	56	29
3/4	3,000	83	71	37
1	3,500	90	76	41
1 1/4	3,900	94	80	44
1 1/2	5,175	102	87	46
1 3/4	5,300	108	92	46
2	5,800	101	87	52
2 1/2	7,300	106	91	58
3	9,000	111	97	64
<i>Electric single-rope grab bucket</i>				
1/4	1,200	51	40	33
3/4	2,600	65	49	46
1	4,600	76	56	48
1 1/4	4,700	88	61	51
1 1/2	4,900	88	61	59
2	9,000	105	73	67
2 1/2	10,000	117	84	60
3	10,500	117	84	70



① SIMPLE TACKLE



② COMPOUND TACKLE

Figure 5.28. Examples of simple and compound tackle.

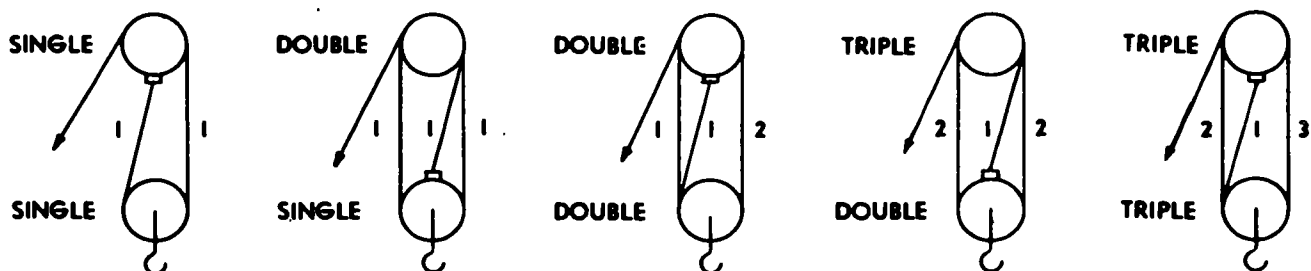


Figure 5.29. Sample block and tackle rigging for manila and wire rope.

5.51 Data on Chain Hoists

1	Differential hoists					Worm-gear hoists					Spur-gear hoists*				
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Capacity (tons)	Lift (ft.)	Approx weight (lb)	Pull chain to lift full load (lb)	Ft of chain overhauled to lift full load 1 ft	Minimum distance between hooks (in.)	Lift (ft)	Approx net weight (lb)	Pull on chain to lift full load (lb)	Ft of chain overhauled to lift full load 1 ft	Minimum distance between hooks (in.)	Lift (ft)	Approx weight (lb)	Pull on chain to lift full load (lb)	Ft of chain overhauled to lift full load 1 ft	Minimum distance between hooks (in.)
1/4	6	22	72	18	17						8	58	50	12 1/2	13
1/2	7	30	122	24	21	8	46	68	40	13	8	58	62	21	13
1	8	51	216	30	26	8	59	87	59	16	8	92	82	31	16
1 1/2	8 1/2	81	246	36	32	8	81	94	80	19	8	132	110	35	18
2	9	122	308	42	49	9	104	115	93	21	9	202	120	42	21
3	9 1/2	180	557	38	44	10	187	132	126	25	10	209	114	69	32
4						10	221	142	155	29	10	299	124	84	37
5						12	331	145	195	31	12	411	110	126	45
6						12	310	145	252	33	12	411	130	126	46
8						12	416	160	310	36	12	500	135	168	49
10						12	578	160	390	45	12	610	140	210	54
12											12	855	260	252	54
16											12	1,041	270	336	62
20											12	1,350	280	420	70

* Spur-gear hoists of 12-, 16-, and 20-ton capacity have two operating chains. The pull on chains (column 14) and the amount of chain overhauled (column 15) is the total for the two chains.

Section V. TERMS

5.52 Stowage

a. Bale Cubic Capacity. The space available for loading cargo, measured in cubic feet to the inside of the cargo battens on the frames and to the underside of the beams. This measurement is used to compute the space available for general cargo.

b. Broken Stowage. The space lost in the hold because of the contour of the ship and the shape of the cargo containers. A typical well-balanced general cargo vessel will have from 10 to 15 percent broken stowage; a complete load of vehicles

will use only 60 to 70 percent of the available cargo space.

c. Grain Cubic Capacity. The maximum space available for cargo measured in cubic feet to the inside of the shell plating and to the underside of the deck plating of a ship. This measurement is used to compute cubic space available for loading bulk commodities.

d. Stowage Factor. The figure that denotes the number of cubic feet required to stow 1 long ton of cargo. This factor is obtained by dividing 2,240 pounds by the weight, in pounds, of a cubic foot of the commodity to be loaded.

5.53 Vessel

a. *After Perpendicular.* The vertical line through the intersection of the afterside of the sternpost with the load water plane.

b. *Base Line.* The intersection of the central longitudinal vertical plane of the ship with a horizontal plane through the top of the keel at the midship section. In some cases the keel line and base line are the same.

c. *Center of Buoyancy.* The center of the molded volume of the vessel below the waterline. It is at the center of gravity of the displaced volume of water. It shifts its position, both vertically and horizontally, as the floating vessel tips. The total upward pressure of the water may be regarded as concentrated through the center of buoyancy, about which it balances. The center of buoyancy and the center of gravity of a ship floating in equilibrium in still water must be in the same vertical line.

d. *Down by the Head and Down by the Stern.* A vessel is down by the head when the bow draft is greater than the stern draft. When the stern draft is greater than the bow draft, the vessel is said to be down by the stern.

e. *Draft and Draft Marks.* Draft marks are 6-inch numerals painted on the bow and stern of a vessel to indicate the depth to which the bow and stern are submerged. The bases of the numerals mark the even foot marks.

f. *Drag.* When the stern is deeper in the water than the bow, the vessel is said to have a drag. The number of feet that the stern is lower is the amount of drag. (This is not to be confused with design drag.)

g. *Forward Perpendicular.* The vertical line through the intersection of the forward side of the stem with the load water plane.

h. *Freeboard.* The vertical distance measured on the vessel's side amidships from the load waterline to the upper side of the freeboard deck or a point corresponding to it.

i. *Full and Down.* A vessel is said to be full and down when all available cubic space has been utilized (full) and sufficient weight is aboard to submerge the vessel to her legal loadline (down).

j. *Hogging.* A vessel is said to be hogging when the weight at both the bow and the stern is greater than at the midships section, thus making the vessel tend to arch up or "hog" amidships.

k. *Keel Line.* The line of the fore and aft mem-

ber running along the centerline of the ship at its lowest part.

l. *Load Waterline (LWL).* The line, viewed horizontally, that represents the intersection of the ship's form with the plane of the surface of the water (load water plane) when the ship is floating with her designed load on board.

m. *Loadline or Plimsoll Mark.* The loadline or Plimsoll mark amidships on the hull of a vessel denotes the maximum draft to which the vessel may be loaded for a particular voyage, depending upon the area to be travelled and the season of the year. The top of the line AB (line S) in figure 5.30 indicates the summer loadline. For ease of observation, the circled line AB is usually placed next to the Plimsoll mark on a vessel that habitually loads in the same kind of water.

n. *Midships Section* . The intersection of the ship's form with a transverse vertical plane midway between the forward and after perpendiculars.

o. *Sagging.* The opposite of hogging. A vessel is said to be sagging when the midships portion has a tendency to sink below the bow and the stern. Sagging is caused by excessive weight amidships and insufficient weight in the bow and stern.

p. *Stiff Ship.* A ship is said to be "stiff" when it has excessive weight in the lower hold and insufficient weight in the 'tween decks. A stiff ship has a tendency to snap back from a roll in a sudden, jarring manner.

q. *Tender Ship.* A vessel with excessive weight in the 'tween decks and insufficient weight in the lower hold. A tender ship has a long, slow roll and a tendency to capsize.

r. *Vessel Factor.* The vessel factor is the bale cubic capacity less estimated lost space divided by the cargo capacity tonnage less estimated weight of the deck cargo. It is the stowage factor for a particular vessel and cargo and should be employed to fully utilize both the cargo space and weight capacity of a vessel. An example of use is shown in (1) and (2) below.

- (1) *Example problem.* Determine the ideal cargo for a Liberty ship with a 400,000 cubic-foot capacity after lost space is deducted and with a cargo capacity tonnage (less deck load) of 8,000 long tons.

(2) *Solution:*

$$\text{Vessel factor} = \frac{400,000}{8,000} =$$

50 cubic feet per long ton

A cargo of 50 cubic feet per long ton would fully utilize both space and weight capacity of the vessel and would therefore be the ideal cargo. A cargo weighing more per unit of volume would make weight the limiting factor, thus wasting some cargo space. A cargo weighing less per unit of volume would make volume the limiting factor, thus wasting some of the weight capacity of the vessel.

5.54 Tonnage

a. *Canal Tonnage (Panama or Suez).* Derived from formulas of measurement prescribed by the respective canal authorities for the assessment of tolls. Space exemptions allowed are not uniform for the two canals, and, as a consequence, ships must carry a certificate for each.

b. *Cargo Deadweight Tonnage.* The total cargo and passenger capacity of a ship expressed in long tons. The figure is computed by deducting the weight of the fuel, water, stores, dunnage, and other items necessary for a voyage from the deadweight tonnage of the vessel.

c. *Deadweight Tonnage.* The carrying capacity of a ship in long tons. It represents the difference

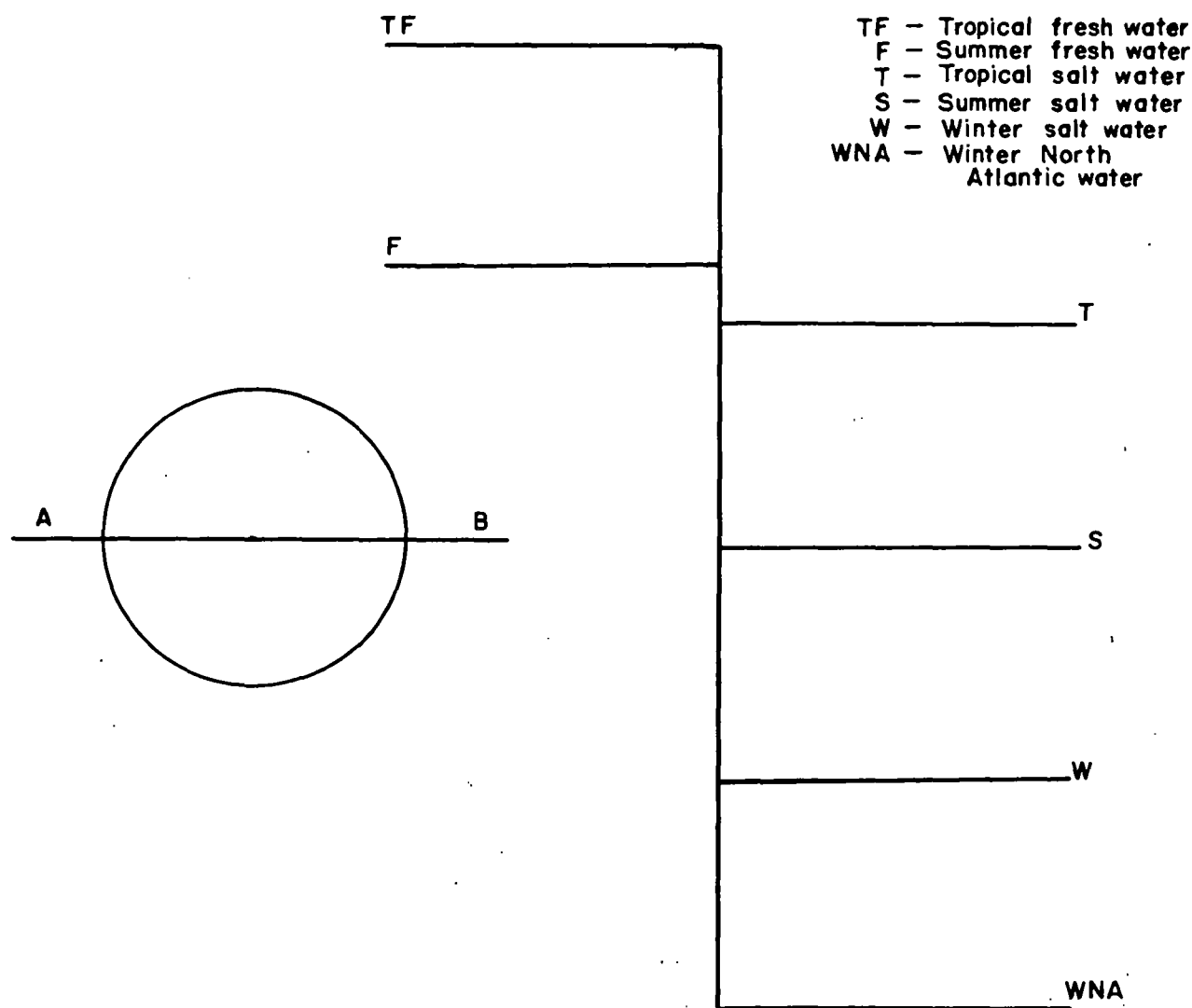


Figure 5.30. Loadline or Plimsoll mark.

between the displacement light and the displacement loaded to the maximum draft allowed by law.

d. *Displacement Ton.* A unit of weight equal to the volume of a long ton of sea water (35 cu. ft.). Used in computing the displacement of vessels.

e. *Displacement Tonnage, Light.* The weight of the ship in long tons excluding cargo, passengers, fuel, water, stores, dunnage, and other items necessary for use on a voyage.

f. *Displacement Tonnage, Loaded.* The weight of the ship in long tons, including cargo, passengers, fuel, water, stores, dunnage, and such other items as necessary for use on a voyage.

g. *Equipment Tonnage.* This is the tonnage arrived at from certain dimensions which take into consideration the exposed surfaces of the vessel both above and below water. It very closely approximates the gross tonnage in a vessel of ordinary construction. Equipment tonnage is used primarily to determine the size of anchors, chains, hawsers, and other ship's gear.

h. *Gross Ton.* A unit of capacity of 100 cubic feet (2.8317 cubic meters) used for ascertaining the legal or registered tonnage of vessels. Also called a *register* or *vessel ton*.

i. *Gross Tonnage.* The entire internal cubic capacity of a ship expressed in gross tons. Also referred to as *gross register tonnage*.

j. *Long Ton.* A unit of weight, 2,240 lb avoirdupois (1016.106 kg), usually divided into 20 hundred-weight (112 lb).

k. *Manifest Ton.* The unit at which cargo is billed or manifested when the carrier has the option to assess freight charges on the basis of a ton weight, or a ton measurement, whichever affords the greater revenue. Also known as a *revenue ton*.

l. *Measurement Ton.* A unit of volume for cargo computed at 40 cubic feet. Also called a *freight ton*, *stevedore ton*, or *ship ton*.

m. *Net Tonnage.* The payload spaces remaining after deduction from the gross tonnage of space for the crew, powerplant, fuel, and operation of the vessel. Net tonnage is expressed in gross tons and is sometimes referred to as *net register tonnage*.

n. *Short Ton.* A unit of weight of 2,000 lb (907.2 Kg).

5.55 Shipping

a. *Bareboat Charter.* A charter in which the bare ship is chartered without crew; the charterer, for a stipulated sum, taking over the vessel with a minimum of restrictions. Also called *demise charter*, *barepole charter*, or *barehull charter*.

b. *Berth Terms.* A form of charter under which

the carrier is responsible for loading and unloading the cargo; these terms apply almost universally to partial cargoes.

c. *Charter Party.* An agreement by which a shipowner agrees to place an entire ship, or a part of it, at the disposal of a merchant or other person for the conveyance of goods, binding the shipowner to transport them to a particular place, for a sum of money which the merchant undertakes to pay as freight for their carriage. Sometimes referred to simply as *charter*. Charters are either time, voyage, or demise (bareboat).

d. *Free Alongside Ship (FAS).* Trade term which implies that the goods should be placed by the shipper within reach of the ship's tackle in a condition fit for shipment. The exact meaning of the word "alongside" is sometimes determined by the custom of the port, but is generally a pure question of fact.

e. *Free In and Out (FIO).* A chartering term that means that the owner who charters his ship is responsible for all the usual costs of ship management with the exception of loading and discharging cargo and of putting the vessel in drydock if required to do so by the charterer.

f. *Free Address (FOA).* A chartering clause which means that no address charges shall be made on the freight at the port of discharge.

g. *Free of Turn.* A chartering term which means that a steamer's time will commence to count for loading or discharging from her arrival, whether there is a berth available or not.

h. *Free on Board (FOB).* A mercantile expression used in sale contracts which denotes that the goods gave to be delivered by the shippers on board the vessel at a particular place, free of all charges.

i. *Free Time.* Chartering term which denotes the duration of time between the moment that the notice of readiness has been handed to the charterers and the beginning of lay days.

j. *Freight Forward.* A term which denotes that under the transportation agreement freight is payable by the consignee at port of destination. The opposite of *freight prepaid*.

k. *Lay Days.* Days allowed by charter party for loading and/or discharging cargo.

l. *Space Charter.* Agreement made between the chartering party and the owner of a vessel which provides that a specified number of cubic feet of shipping space is allocated by means of voyage commitment orders for use on specified voyages from and to designated ports.

Section VI. MISCELLANEOUS

5.56 Approximate Sailing Distances in Nautical Miles

Distances shown below are in nautical miles because international distances over water are normally expressed in this unit of measure. To convert to statute miles, multiply by 1.15155; to convert to kilometers, multiply by 1.85325.

Distance from—	Distance to—						
	Boston	New York	Charleston	New Orleans	Los Angeles	San Francisco	Seattle
Caribbean and South America:							
Argentina, Buenos Aires.....	5,800	5,900	5,800	6,300	^a 8,300	^a 8,700	^a 9,600
Brazil, Rio de Janeiro.....	4,700	4,800	4,700	5,200	^a 7,200	^a 7,600	^a 8,400
Chile, Valparaiso.....	^a 4,800	^a 4,600	^a 4,200	^a 4,100	4,800	5,100	5,900
Panama, Panama.....	2,200	2,000	1,600	1,400	2,900	3,200	4,000
Puerto Rico, San Juan.....	1,500	1,400	1,100	1,500	^a 3,900	^a 4,300	^a 5,100
Trinidad, Port of Spain.....	2,000	1,900	1,700	2,100	^a 4,100	^a 4,400	^a 5,300
Europe:							
Belgium, Antwerp.....	3,200	3,400	3,800	4,800	^a 7,700	^a 8,000	^a 8,800
France:							
Bordeaux.....	3,000	3,200	3,700	4,700	^a 7,600	^a 7,900	^a 8,700
Brest.....	2,900	3,100	3,500	4,500	^a 7,400	^a 7,700	^a 8,500
Le Havre.....	3,000	3,200	3,600	4,600	^a 7,500	^a 7,800	^a 8,600
Norway, Oslo.....	3,900	4,100	4,400	5,300	^a 8,200	^a 8,600	^a 9,400
United Kingdom:							
Belfast.....	2,900	3,000	3,400	4,400	^a 7,200	^a 7,500	^a 8,300
Liverpool.....	3,000	3,200	3,700	4,700	^a 7,600	^a 7,900	^a 8,700
Southampton.....	3,000	3,200	3,600	4,600	^a 7,500	^a 7,800	^a 8,600
Far East:							
China, Shanghai.....	^a 10,800	^a 10,600	^a 10,800	^a 10,000	5,700	5,400	5,100
Formosa, Keelung.....	^a 10,932	^a 10,750	^a 10,339	^a 10,176	5,858	5,570	5,310
Hong Kong.....	^a 11,400	^a 11,200	^a 10,800	^a 10,600	6,400	6,000	5,700
Japan, Yokohama.....	^a 9,900	^a 9,600	^a 9,500	^a 9,100	4,800	4,500	4,200
Korea, Pusan.....	^a 10,547	^a 10,365	^a 9,954	^a 9,791	5,229	4,914	4,649
India-Burma-Pakistan:							
Burma, Rangoon.....	^b 9,600	^b 9,800	^b 10,200	^b 11,200	9,000	8,600	8,200
					^a ^b 13,900	^a ^b 14,200	^a ^b 15,000
India:							
Bombay.....	^b 8,000	^b 8,200	^b 8,600	^b 9,500	^a ^b 12,200	^a ^b 12,600	^a ^b 13,400
					10,300	9,800	9,500
Calcutta.....	^b 9,600	^b 9,800	^b 10,200	^b 11,200	^a ^b 13,900	^a ^b 14,200	^a ^b 15,000
					9,500	9,000	8,700
Pakistan, Karachi.....	^b 7,800	^b 8,200	^b 8,400	^b 9,300	10,700	10,200	9,900
					^a 12,000	^a 12,400	^a 13,200
Mediterranean:							
Algeria, Algiers.....	^b 3,400	^b 3,600	^b 4,000	^b 5,000	^a ^b 7,700	^a ^b 8,000	^a ^b 8,800
France, Marseilles.....	^b 3,700	^b 3,900	^b 4,300	^b 5,300	^a ^b 8,000	^a ^b 8,200	^a ^b 9,000
Greece, Piraeus.....	^b 4,500	^b 4,700	^b 5,100	^b 6,100	^a ^b 7,800	^a ^b 8,100	^a ^b 8,900
Italy:							
Leghorn.....	^b 3,900	^b 4,100	^b 4,500	^b 5,500	^a ^b 8,200	^a ^b 8,400	^a ^b 9,200
Naples.....	^b 4,000	^b 4,200	^b 4,600	^b 5,600	^a ^b 8,300	^a ^b 8,500	^a ^b 9,300
Lebanon, Tripoli.....	^b 4,100	^b 4,300	^b 4,700	^b 5,700	^a ^b 8,400	^a ^b 8,600	^a ^b 9,400
Strait of Gibraltar.....	3,000	3,200	3,600	4,600	^a 7,300	^a 7,500	^a 8,300
Middle East:							
Aden.....	^b 6,300	^b 6,500	^b 6,900	^b 7,900	^a 10,600	^a 10,900	^a 11,700
Egypt, Port Said.....	^b 4,900	^b 5,110	^b 5,500	^b 6,500	^a 9,200	^a 9,500	^a 10,300
Iraq, Basra.....	^b 8,300	^b 8,500	^b 8,900	^b 9,800	^a 12,600	^a 12,900	^a 13,700
Turkey, Istanbul.....	^b 4,800	^b 5,000	^b 5,400	^b 6,400	^a 9,100	^a 9,400	^a 10,200

See footnotes at end of table.

Distance from—	Distance to—						
	Boston	New York	Charleston	New Orleans	Los Angeles	San Francisco	Seattle
Middle Pacific:							
Hawaii, Honolulu	^a 6,900	^a 6,700	^a 6,300	^a 6,100	2,200	2,100	2,400
Marianas Islands, Guam	^a 10,200	^a 10,000	^a 9,600	^a 9,400	5,600	5,100	4,900
Marshall Islands, Kwajalein	^a 9,200	^a 9,000	^a 8,600	^a 8,400	4,200	4,410	4,500
North Atlantic:							
Bermuda, Hamilton	700	700	800	1,700	^a 4,600	^a 4,900	^a 5,800
Greenland, Ivigtut	1,700	1,900	2,400	3,400	^a 6,500	^a 6,800	^a 7,600
Iceland, Reykjavik	2,300	2,500	3,000	4,000	^a 7,100	^a 7,400	^a 8,200
Newfoundland, St. Johns	900	1,100	1,700	2,600	^a 5,700	^a 6,000	^a 6,800
North Pacific:							
Alaska, Dutch Harbor	^a 7,400	^a 7,300	^a 6,900	^a 6,700	2,400	2,100	1,700
Southwest Pacific:							
Australia:							
Brisbane	^a 9,900	^a 9,600	^a 9,300	^a 9,100	6,300	6,200	6,500
Melbourne	^a 10,100	^a 9,900	^a 9,500	^a 9,400	7,000	7,000	7,300
Indonesia, Djakarta	^b 10,200	^b 10,400	^b 10,800	^a 12,000	8,100	7,600	7,300
				^b 11,800			
Malaya, Singapore	^b 9,900	^b 10,100	^b 10,500	^b 11,500	7,900	7,500	7,100
New Guinea, Finschafen	^a 10,200	^a 10,000	^a 9,600	^a 9,400	6,100	5,900	6,000
Philippines, Manila	^a 11,600	^a 11,300	^a 11,000	^a 10,800	6,600	6,300	6,100
Union of Soviet Socialist Republics:							
Archangel	4,000	4,200	4,800	5,800	^a 8,800	^a 9,200	^a 10,000
Murmansk	3,700	3,800	4,400	5,400	^a 8,500	^a 8,900	^a 9,700
Vladivostok	^a 9,500	^a 9,300	^a 8,900	^a 8,700	5,000	4,600	4,400
United States:							
Boston		200	900	2,000	^a 5,100	^a 5,400	^a 6,200
Charleston	900	600		1,200	^a 4,500	^a 4,900	^a 5,600
Los Angeles	^a 5,100	^a 4,900	^a 4,500	^a 4,300		400	1,100
New Orleans	2,000	1,700	1,200		^a 4,300	^a 4,700	^a 5,500
New York	200		600	1,700	^a 4,900	^a 5,300	^a 6,000
San Francisco	^a 5,400	^a 5,300	^a 4,900	^a 4,700	400		800
Seattle	^a 6,200	^a 6,000	^a 5,600	^a 5,500	1,100	800	

^a Via Panama Canal.

^b Strait of Gibraltar.

5.57 United States Buoyage System (fig. 5.31)

a. Buoys are wooden or metal floats of various shapes, sizes, and colors anchored to the bottom of harbors, bays, rivers, and channels. They are the road markers of the sea. The primary function of a buoy is to warn the mariner of some danger, obstruction, or change in the contours of the sea bottom, and to delineate the channels leading to various points, so that he may avoid the dangers and continue his course safely. The different types of buoys are identified by size, shape, coloring, numbering, and the signaling devices with which they are equipped. They are marked on charts so that the mariner can plot his course to avoid the potential hazards indicated.

b. The buoyage system used in United States waters employs a simple arrangement of colors, shapes, numbers, and light characteristics to show

the side on which a buoy should be passed when proceeding in a given direction. The characteristics are determined by the position of the buoy with respect to the navigable channels as the channels are entered from seaward. As all channels do not lead from seaward, arbitrary assumptions have been applied at times in order to keep the system consistent, and the operator should consult the aids shown on his chart to determine the seaward direction of a channel. Some mariners use the expression "red right returning" to keep in mind the proper position of these buoys in relation to their vessels. The principal types of buoys are described below:

- (1) A spar buoy is usually a large log, trimmed and appropriately painted; it may also be constructed of steel plates, joined to form a slim cylinder. The shape of a spar buoy has no significance: it is

used for any purpose. Coloring reveals the particular meaning of the buoy.

- (2) A can buoy is constructed of steel plates and its shape is similar to that of an ordinary tin can. Normally it is used to designate the port side (entering from seaward), but may be used to mark the middle of a channel, a junction, or an obstruction. Color indicates the particular meaning. A can buoy is never used to mark the starboard side of a channel when entering from seaward.
- (3) A nun buoy is also constructed of steel plates and has a conical top. It is normally used to mark the starboard side of the channel, but may also be used for mid-channel, junction, or obstruction marking; the color denotes the particular purpose. A nun buoy is never used on the port side of a channel.
- (4) A lighted buoy is a metal float on which is mounted a short skeleton tower with a lantern at the top. It has no shape significance; its purpose is indicated by color.
- (5) Bell buoys, gong buoys, and whistle buoys are metal floats with sound equipment installed. No special significance is attached to their shapes.

c. All United States buoys are painted with distinctive colors to indicate their purpose or the side on which they should be passed when entering from seaward.

- (1) A black buoy marks the port side of a channel, or the location of obstructions which must be passed by keeping the buoy on the portside of the vessel when entering from seaward. It displays white or green lights at night.
- (2) A red buoy marks the starboard side of a channel, or the location of obstructions which must be passed by keeping the buoy on the starboard side. It displays white or red lights at night.
- (3) A red and black horizontally banded buoy marks a junction in the channel or an obstruction which may be passed on either side. If the topmost band is black, the preferred channel will be followed by keeping the buoy on the port side when proceeding from seaward; if the topmost band is red, the preferred channel will be followed by keeping the buoy

on the starboard side. This buoy may have white, red, or green lights.

- (4) A black and white vertically striped buoy marks the fairway or mid-channel, and should be passed close to, on either side. It displays a white light at night.
- (5) Special-purpose buoys have distinctive colors and are usually spar buoys. They reveal the locations of anchorage areas, dredging operations, etc.
- (6) Buoys used on the Intracoastal Waterway are similar to the preceding ones, but are characterized by a yellow border, and are discussed and illustrated in CG-193.

d. Buoys indicating the starboard side are marked with even numbers; those indicating the port side are marked with odd numbers. Mid-channel, junction, and special-purpose buoys are not numbered, but may be lettered for identification. An example is the East Rockaway Inlet Bell Buoy, which carries black and white vertical stripes and the letters ER-ER standing for the station name.

e. Usually only buoys in key spots have lights; some unlighted buoys have reflectors which may be white, red, or green, and have the same significance as lights of the same colors. Black buoys have green or white lights; red ones have red or white lights. Mid-channel buoys use white only, while obstruction (junction) buoys use the appropriate color to reveal the preferred channel. Channel buoy lights are usually slow flashing (not over 30 flashes per minute). If they mark important turns or dangerous areas, they will be quick flashing with 60 or more flashes per minute. Red and black horizontally banded buoys have interrupted quick flashing lights—a series of quick flashes with dark intervals of about 4 seconds between series. Mid-channel buoys have short-long flashing lights—groups consisting of a short flash and a long flash repeated at the rate of about eight per minute.

5.58 Storm Warning Signals

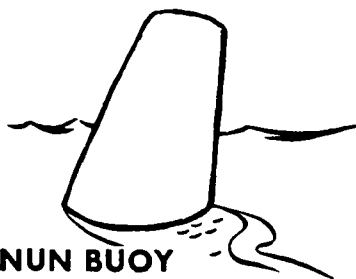
(fig. 5.32)

a. *Small Craft Warning.* One red pennant displayed by day or a red light over a white at night indicates winds up to 38 miles an hour (61 kilometers per hour) (33 knots) and/or sea conditions dangerous to small craft operations.

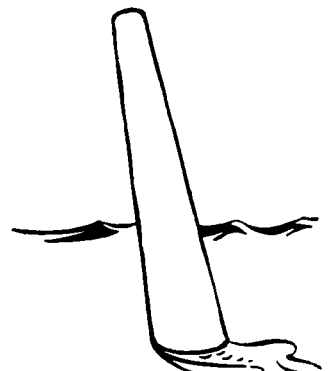
b. *Gale Warning.* Two red pennants displayed by day or a white light above a red light at night



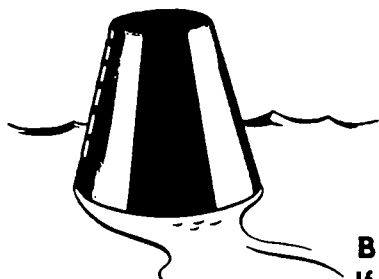
CAN BUOY
Marking Port Side of
Channel From Seaward



NUN BUOY
Marking Starboard Side of
Channel From Seaward



SPAR BUOY



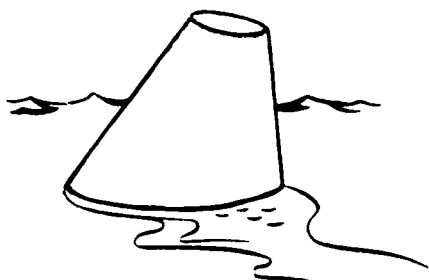
**MIDCHANNEL OR
FAIRWAY MARKER**



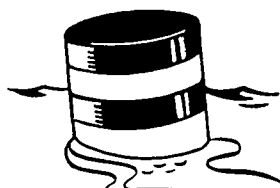
BUOY MARKING OBSTRUCTION
If Top Band Is Red, Keep Buoy To Starboard.
If Top Band Is Black, Keep Buoy To Port.



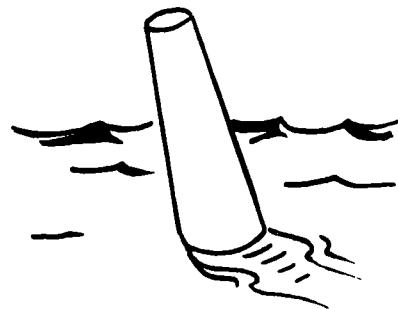
**BUOY MARKING
DREDGING AREA**



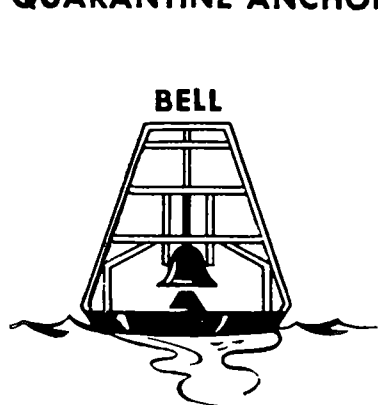
QUARANTINE ANCHORAGE



FISH TRAP OR NET MARKER



**ANCHORAGE
AREA**



BELL



LIGHTED

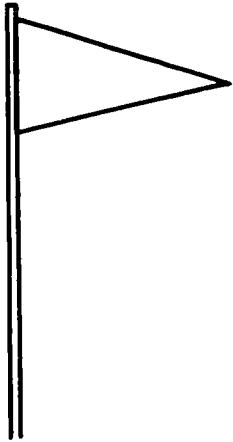


WHISTLE

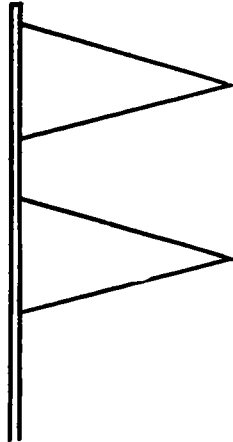
Figure 5.31. Buoyage system used in United States waters.

DAYTIME SIGNALS

SMALL CRAFT



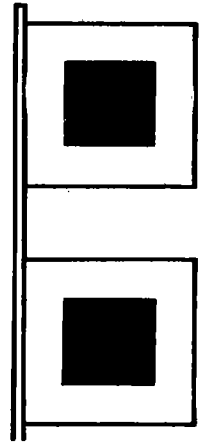
GALE



WHOLE GALE

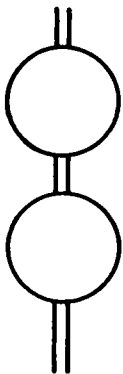


HURRICANE

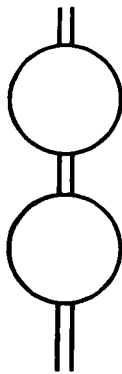


NIGHT SIGNALS

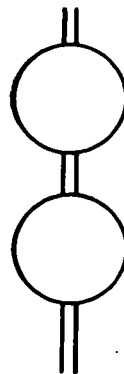
SMALL CRAFT



GALE



WHOLE GALE



HURRICANE

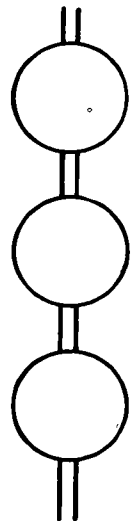


Figure 5.32. Storm warning signals.

indicate winds ranging from 39 to 54 miles an hour (63 to 87 kilometers per hour) (34 to 48 knots).

c. Whole Gale Warning. A single square red flag with a black center displayed during daytime or two red lights at night indicate winds ranging from 55 to 73 miles an hour (89 to 118 kmph) (48 to 63 knots).

d. Hurricane Warning. Two square red flags with black centers displayed by day or a white light between two red lights at night indicate winds 74 miles per hour (119 kmph) (64 knots) and above.

5.59 Beaufort's Scale

Beaufort No.	Description of wind	Miles per hour (statute)	Miles per hour (nautical)
0	Calm.....	Less than 1	Less than 1
1	Light air.....	1-3	1-3
2	Light breeze.....	4-7	4-6
3	Gentle breeze.....	8-12	7-10
4	Moderate breeze.....	13-18	11-16
5	Fresh breeze.....	19-24	17-21
6	Strong breeze.....	25-31	22-27
7	Moderate gale.....	32-38	28-33
8	Fresh gale.....	39-46	34-40
9	Strong gale.....	47-54	41-47
10	Whole gale.....	55-63	48-55
11	Storm.....	64-75	56-65
12	Hurricane.....	Above 75	Above 65

CHAPTER 6

PLANNING

The formats included in this chapter have been appropriately condensed for the transportation planner. Normally, these formats apply only in the initial stages of planning. See FM 101-5 for more detailed information and AR 380-5 for classification procedures.

Section I. ORDERS AND STANDING OPERATING PROCEDURES

6.1 Operation Order

COPY No. _____
Issuing headquarters
Place of issue (may be in code)
Date-time group of signature
Message reference number

Operation order: Type and serial number. (Type is usually indicated in combined or joint operations but omitted within a single service. When required, a code title may also be included.)

References: Maps, charts, and other relevant documents.

Time zone: Used throughout the order; if unnecessary, omit.

Task organization: Task subdivisions or tactical components of the command and names and ranks of the commanders. (When a task organization is not listed, this information is included in paragraph 3 or in an annex.)

1. **SITUATION.** General information on the overall situation required to understand current circumstances.

a. Enemy forces. Composition, disposition, location, movement, estimated strength, identification, and capability.

b. Friendly forces. Information on forces, other than those covered by this order, which may directly affect actions of subordinates.

c. Attachments and detachments. Units attached to or detached from the issuing unit (if not shown under task organization) and effective times. (If shown under task organization, appropriate reference is listed here.)

2. **MISSION.** A clear, concise statement of the task to be accomplished by the command and purpose of the task.

3. **EXECUTION**

a. First subparagraph. Concept of the operation, including the commander's general plan for development and phasing of the operation, use of fire support, instructions on preparatory fires, and designation of unit making the main effort.

b. Following subparagraphs. Specific tasks of each element charged with executing tactical missions, including the organization for combat (if not given under task organization).

c. Final subparagraph "Coordinating Instructions." Details of coordination and control measures applicable to the command as a whole, in addition to instructions necessary for coordination or the general conduct of the operation and which apply to two or more elements if repetition in preceding subparagraphs would be cumbersome.

4. **ADMINISTRATION AND LOGISTICS.** Administrative instructions and method of providing combat service support for the operation, including allocation of critical supply items and special ammunition loads. Reference is made to any administrative order in effect or being issued separately. Subparagraphs following the sequence of the administrative order are included as required.

5. **COMMAND AND SIGNAL.** Instructions, including reference to a standard plan or annex on rendezvous, location, and movements of commander and command posts, statement of command relationship reference to signal operating instructions, electronic policy, and liaison.

ACKNOWLEDGMENT INSTRUCTIONS

Commander (name and grade)

Annexes
Distribution
Authentication

6.2 Logistics Annex to Operation Plan or Order

COPY No. _____
Issuing headquarters
Place of issue (may be in code)
Date-time group of signature
Message reference number

Annex _____ (logistics) to Operation Plan _____

References: Maps, charts, and other relevant documents.

1. **GENERAL SITUATION.** Information on the overall situation essential to understanding the logistical plan.

a. *Enemy forces.* Composition, disposition, location, movement, estimated strength, identification, and capability.

b. *Friendly forces.* Commanders' responsibilities affecting the logistical plan.

c. *Attachments and detachments.* Units attached to or detached from the issuing unit and effective times.

d. *Assumptions.* Assumptions on which the plan is based (normally applicable only to higher planning echelons).

2. **MISSION.** A clear, concise statement of the task to be accomplished by the command and the purpose of the task.

3. **TASKS FOR SUBORDINATE UNITS.** Separate, lettered subparagraphs giving the specific task or responsibility of each subordinate command.

4. **MATERIEL AND SERVICES.**

a. *Supply.*

(1) *Installations.* Instructions to installation commanders on missions, issue and collection of supplies and material, locations and times of opening or closing of installations, operating units, supported units, stocks and levels, credits, and type of storage.

(2) *Requirements.* General statement on tonnage requirements, levels of supply to be achieved during different periods, and special information on certain items, such as water supply in the area where water is scarce.

(3) *Requisition and procurement.* Information on normal requisitioning and on local procurement.

(4) *Distribution.* Instructions on receipts, shipments, and issues.

(5) *Civilian supplies.* Instructions on issuing supplies to civilians.

(6) *Salvage.* Instructions on collection, classification, and disposition of salvage.

(7) *Captured supplies.* Instructions on reports, collection, segregation, and disposition of captured materials.

(8) *Responsibilities.*

b. *Transportation.*

(1) *General.* General information on policies.

(2) *Motor.* Traffic regulation and control.

(3) *Rail.* Locations, facilities, capacities, and restrictions.

(4) *Water.* Ports and beaches in use and to be placed in use, facilities, capacities, and restrictions. (Separate subparagraphs for ocean, coastal, and inland waterways.)

(5) *Pipelines.* Locations, sizes, capacities, and restrictions.

(6) *Air.* Airfield capacities and restrictions.

(7) *Transportation movements.* Instructions for management of the movement capability.

(8) *Responsibilities.*

c. *Services.*

(1) *Organization.* Service groups, trains, and depots; bivouacs and movement of unit trains; assignment or attachment of service units to subordinate units or commands.

(2) *Technical services.* Service installations, locations, operating units, and assignments to supported units; special missions, priorities, schedules, and limitations not covered in other orders. (May be divided more simply by types, such as maintenance, construction, utilities, and real estate.)

(a) *Chemical.* Decontamination, impregnation, and maintenance.

(b) *Engineer.* Construction, fire fighting, maintenance, procurement, real estate, reproduction, and utilities.

(c) *Medical.* Medical, dental, and veterinary; laboratory, spectacle; special hospitalization, preventive medicine, health, and sanitation.

(d) *Ordnance.* Inspection, maintenance, procurement, waterproofing, and bomb disposal.

(e) *Quartermaster.* Bathing and fumigation, labor, laundry maintenance, personal effects service, procurement sales, remount service, and responsibility for salvage and petroleum supply and testing.

(f) *Signal.* Signal communication, construction, photography, and maintenance.

(g) *Transportation.* Procurement, supply, and maintenance, covering all modes.

(3) *Labor.* Policies pertaining to the use of civilian (U. S. and non-U. S.) and prisoner-of-war personnel.

(4) *Responsibilities.*

5. MEDICAL: EVACUATION AND HOSPITALIZATION.

a. *Evacuation.* Dispensaries and clearing stations, locations, times of opening or closing, operating units, and units supported; policies, estimated rates, and channels for evacuation of injured, sick, and wounded, including prisoners of war and civilians.

b. *Hospitalization.* General instructions for all personnel, including prisoners of war and civilians, policies, locations, and capacities of hospitals.

c. *Responsibilities.*

6. MISCELLANEOUS.

a. *Boundaries.* Locations—present and proposed.

b. *Headquarters.* Locations of headquarters and instructions for movement.

c. *Security.* Instructions for protection and defense of installations and facilities.

d. *Area damage control.* Measures to reduce damage potential in logistical installations, including instructions pertaining to traffic control (may be issued as an overlay), evacuation, and hospitalization.

e. *Reports.* Types required, time due, and subject matter covered.

f. *Conservation of supplies.* General instructions for safeguarding, use, maintenance, and conservation of supplies.

g. *Effective date of plan.*

h. *Responsibilities.*

ACKNOWLEDGMENT INSTRUCTIONS.

Commander (name and grade)

Appendixes
Distribution
Authentication

6.3 Administrative Order

(Subparagraphs which do not apply are omitted.)

COPY No. _____
Issuing headquarters
Place of issue (may be in code)
Date-time group of signature
Message reference number

Administrative order: Type and serial number.
(Type is usually indicated in combined or joint operations but omitted within a single service. When required, a code title may also be included.)

References: Maps, charts, and other relevant documents.

Time zone: Used throughout the order; if unnecessary, omit.

1. **GENERAL.** Outline of the administrative plan; any orders that are not suitably covered by succeeding paragraphs; e.g., location of administrative area in a divisional order (may be issued as an annex or overlay); and traffic circulation plan (may be issued as an annex or overlay).

2. **MATERIEL AND SERVICES.** Supplies (normal daily requirements), either by types of supply or by branches of service, transport, transportation services, repair and recovery (maintenance), construction, other services, allocation of labor, etc., in the order suitable to the staff procedures of the army concerned.

a. *Supply.* Installations concerned with the issue and collection of supplies and material; locations and, where applicable, time of opening or closing; operating units; supported units; stocks and levels; and credits. Instructions on submission of nonroutine reports or temporary changes regarding the submission of routine reports concerning the particular supplies listed; removal, collection, and disposition of, and reports concerning excess, salvage, and captured supplies; overall levels of supply; and methods or schedules of supply distribution. Organized in one of or a combination of the following methods:

<i>Class of supply</i>	<i>Branch of supply</i>	<i>Type of installations</i>
(1) Class I	(1) Chemical	(1) General depot
(2) Class II	(2) Engineer	(2) Branch depot
(3) Class III	(3) Medical	(3) Supply point
(4) Class IV	(4) Ordnance	(4) Railhead
(5) Class V	(5) Quartermaster	(5) Truckhead
(6) Maps	(6) Signal	(6) Miscellaneous
(7) Water	(7) Transportation	
(8) Special	(8) Miscellaneous	
(9) Excess		
(10) Salvage		
(11) Captured materiel		

b. *Transportation.* Terminals and installations (rail stations, airfields, ports, and beaches), operating units, schedules (march tables, time tables,

and entraining tables), control measures (traffic regulation and control, allocations, priorities, restrictions, route markings, and regulating points). (Items cover the entire transportation field and are not necessarily restricted to Transportation Corps operations.)

- | | |
|---------------------|-------------------|
| (1) Ocean | (5) Rail |
| (2) Inland waterway | (6) Pipeline |
| (3) Coastal | (7) Air |
| (4) Motor | (8) Miscellaneous |

c. Services.

(1) *Organization.* Service groups, trains, and depots; bivouacs and movement of unit trains; assignment or attachment of service units to subordinate units or commands.

(2) *Technical services.* Service installations, locations, operating units, and assignments to supported units, and special missions not covered in other orders.

- | | |
|--------------|--------------------|
| (a) Chemical | (e) Quartermaster |
| (b) Engineer | (f) Signal |
| (c) Medical | (g) Transportation |
| (d) Ordnance | |

d. Labor. Policies pertaining to the use of civilian (non-U. S. and U. S.) and prisoner-of-war personnel.

3. MEDICAL: EVACUATION AND HOSPITALIZATION.

a. Evacuation. Dispensaries, collecting stations, and clearing stations; locations, times of opening or closing; operating units; and units supported; routes, means, schedules, and responsibilities for evacuation; evacuation and treatment policies.

b. Hospitalization. Hospitals (evacuation, station, general, field, convalescent); locations, times of opening or closing; and units supported.

4. PERSONNEL. Reporting procedures, replacement, discipline, law and order, prisoners of war, burials, morale, welfare, civilian employees, etc., in the order suitable to the staff procedures of the headquarters concerned. Under each subparagraph or specific personnel activity the following are listed when applicable: the operating installation, service, or depot; location and hour and date of opening or closing; the units operating the installation; attachment or assignment of operating personnel; the units or areas served; credits or quotas allocated to units; unit responsibility for movement or administration of personnel; reports required; requisitions or

plans concerning personnel activities; references to previous orders, instructions, or standing operating procedure.

a. Strengths. Instructions for presenting personnel strengths.

b. Replacements. Requirements (present and anticipated), requisitioning, allocating, processing and moving replacements, location and stockage of replacement units, and location of unit replacements.

c. Discipline, law, and order. Troop conduct and appearance, control and disposition of stragglers, administration of military justice, and relations with civilians.

d. Prisoners of war. Collection, safeguarding, processing, evacuation, utilization, treatment, and discipline.

e. Recovery and disposition of remains. Cemeteries, evacuation, personal effects, and ceremonies.

f. Morale and personnel services.

(1) *Morale.* General instructions concerning morale.

(2) *Personnel services.* Leaves, rest and recreational facilities, decorations and awards, postal and finance services, religious activities, personal hygiene, special service activities, Army exchanges, welfare activities, and legal assistance.

g. Personnel procedures. Classification, assignment, promotion, transfer, reclassification, demotion, elimination, retirement, separation, training rotation, and personnel economies.

h. Headquarters management. Movement, internal arrangement, organization, and operation; allocation of shelter for headquarters personnel.

i. Civilian personnel. Sources, procurement, utilization, administration, control, relation to military government, and relation to troops.

j. Miscellaneous. Personnel matters not specifically assigned to another general staff section.

5. CIVIL AFFAIRS. Allocation and deployment of civil affairs (CA) units, control of refugees, feeding and treatment of civil population, etc.

a. Civil affairs units. Locations of all CA units in area; procedures for requesting support of these units.

b. Government. Establishment of relationship between military and civil authorities; instructions for tactical units on seizure and protection of government offices, records, and personnel; issu-

ance of proclamations, laws, ordinances, and notices.

- (1) *Law*. Jurisdiction of legal framework; authorization for closing local, criminal, and civil courts; authorization and procedures for military courts.
- (2) *Public order and safety*. Measures for control of, or assistance to, local government to restore public order and safety; collection and disposition of arms, ammunition, explosives, etc.; civil defense and integration of civil defense and military warning systems; control of liquor and narcotics.

c. Economy. Protection and prevention of exploitation of natural resources and other economic necessities.

- (1) *Commerce and industry*. Designation of "Off Limits" areas. Specific responsibilities for safeguarding essential commerce and industry.
- (2) *Food and agriculture*. Procedures for safeguarding agricultural stocks and food supplies; restrictions on troop use.
- (3) *Price control and rationing*. Prevention of black marketing; control of requisitioning and purchasing of civilian supplies.
- (4) *Property control and protection*.
- (5) *Public finance*. Requirements for securing banks and funds; restriction of currency.
- (6) *Civilian supply*. Use of civilian and military supplies for aid to civilians; procedures for distribution.
- (7) *Labor*. Procurement of labor; restrictions on employment of civilians.
- (8) *Public works and utilities*. Reestablishment as required; authorized military use.
- (9) *Public transportation*. Reestablishment as required; authorized military use.
- (10) *Public communications*. Reestablishment, protection, restrictions, and censorship; authorized military use.
- (11) *Civil information*. Control and military use.

d. Public welfare.

- (1) *Health*. Prevention and treatment of disease.
- (2) *Relief and supply*. Minimum requirements for food, clothing, and shelter; provision, if necessary.

- (3) *Education*. Preservation of educational systems and facilities; control measures.
- (4) *Refugees and displaced persons*. Control, care, and disposition; location of facilities; instructions for evacuation requests.
- (5) *Arts, monuments, and archives*. Security and protection.

e. Miscellaneous. Special instructions pertaining to civil affairs not covered above.

6. MISCELLANEOUS. Any special instructions not covered above.

- a. Boundaries*.
- b. Headquarters*.
- c. Security*.
- d. Area damage control*.
- e. Reports*.
- f. Other administrative and logistical matters*.

ACKNOWLEDGEMENT INSTRUCTIONS.

Commander (name and grade)

Annexes
Distribution
Authentication

6.4 Transportation Annex to Administrative Order (Sample)

COPY No. _____
10th U. S. Army
Location: (coordinates)
Time and date: _____

Annex _____ (Transportation) to ADMINO
No. _____

References: Maps, charts, and other relevant documents.

1. SITUATION

a. Intelligence report No. _____, Hq 10th U. S. Army, dated _____.

b. Operations report No. _____, Hq 10th U. S. Army, dated _____.

c. TALOG furnishes necessary rail and water terminal transportation service in support of 10th U. S. Army.

d. 5th U. S. Air Force furnishes necessary air transportation service in support of 10th U. S. Army.

2. MISSION

Transportation elements will provide transportation service support for assigned and attached troops of 10th U. S. Army and transportation service support for Air Force units to base level.

3. EXECUTION

a. 48th Trans Gp (Trk), _____, furnishes highway transportation service as directed.
(coordinates)

(1) 264th Trans Bn (Trk), _____.
(coordinates)

(2) 265th Trans Bn (Trk), _____.
(coordinates)

(3) 266th Trans Bn (Trk), _____.
(coordinates)

(4) 267th Trans Bn (Trk), _____.
(coordinates)

b. 54th Trans Gp (Trk), _____, furnishes highway transportation service as directed.
(coordinates)

(1) 465th Trans Bn (Trk), _____.
(coordinates)

(2) 467th Trans Bn (Trk), _____.
(coordinates)

(3) 468th Trans Bn (Trk), _____.
(coordinates)

(4) 469th Trans Bn (Trk), _____.
(coordinates)

(5) 488th Trans Bn (Trk), _____.
(coordinates)

c. 429th Trans Gp (TAAM & Sup), _____, furnishes field maintenance and supply support for Army fixed-wing and rotary-wing aircraft as required.
(coordinates)

(1) 233d Trans Bn (TAAM & Sup, DS), _____.
(coordinates)

(2) 234th Trans Bn (TAAM & Sup, DS), _____.
(coordinates)

(3) 235th Trans Bn (TAAM & Sup, DS), _____.
(coordinates)

(4) 322d Trans Bn (TAAM & Sup, GS), _____; operates depot 631, CI III-A items only, 5-day level; operates depot 632, CI IV-A items only, 10-day level; supports all Army aircraft maintenance units.
(coordinates)

d. 112th Trans Bn (Transport Acft), _____.
(coordinates)

(1) Annex G (Army Aviation to OPORD No. 8, Hq 10th U. S. Army, dated _____).

(2) Furnishes administrative support to Hq, 10th U. S. Army.

e. 113th Trans Bn (Transport Acft), _____: Annex G (Army Aviation) to OPORD No. 8, Hq 10th U. S. Army.
(coordinates)

f. 433d Trans Bn (Trk), _____, attached to 1st Corps effective _____.
(coordinates)

g. 263d Trans Bn (Trk), _____, attached to 2d Corps effective _____.
(coordinates)

h. 463d Trans Bn (Trk), _____, attached to 3d Corps effective _____.
(coordinates)

i. 257th Trans Gp (Trans Movements), _____, regulates transportation movements within army area; operates TMO's and maintains liaison with appropriate technical services.
(coordinates)

j. 230th Trans Co (Car), _____, supports Hq, 10th U. S. Army.
(coordinates)

k. 3460th, 3461st, and 3462d Trans Intelligence Teams (HA-Collection), _____, perform information collection missions for Transportation Section, Hq, 10th U. S. Army.
(coordinates)

l. 2460th Trans Intelligence Team (HB-Research), _____, produces and reports transportation technical intelligence for Transportation Section, Hq, 10th U. S. Army; selects, processes, and expedites the flow of enemy transportation materiel.
(coordinates)

m. Alternate command posts and dispersal areas will be selected and maintained. All transportation units will be prepared to relocate on order.

n. Units will be prepared to perform secondary mission as infantry.

4. ADMINISTRATION AND LOGISTICS

a. Supply.

(1) Supply levels.

(a) Primary depot—10 days.

(b) Secondary depot—5 days.

(2) Regulated items.

(a) Aircraft.

(b) All engines and power trains.

(3) Resupply.

Requisition schedule—10th and 25th day each month; equipment out of commission for parts—requisition as necessary.

b. Service.

(1) Transportation: Annex G, 10th U. S. Army SOP.

(2) Loading and unloading: Responsibility of consignors and consignees.

5. COMMAND AND SIGNAL

a. Reports: Annex F, 10th U. S. Army SOP.

b. Army Transportation Officer: _____,
(coordinates)
phone _____.

c. Communications: Annex G, 10th U. S. Army
SOP.

ACKNOWLEDGMENT INSTRUCTIONS

Commander (name and grade)

Appendixes
Distribution
OFFICIAL

/s/

/t/

ACofS, G-4

6.5 Outline for Transportation Standing Operating Procedure for Major Com- mands

STANDING OPERATING PROCEDURE

(command)

1. PURPOSE. Outline of purpose.
2. SCOPE. Application and coverage.
3. UNIT PROCEDURES. Action required by subordinate units in preparation of unit SOP, including a definite statement that SOP procedures of subordinate units will be based on and conform to the SOP procedures of the issuing command.
4. RECISIONS. Any publications superseded or recinded by the SOP, including fragmentary SOP's, orders, memorandums, bulletins, or other directives.
5. REFERENCES. Publications to be used in conjunction with the SOP.
6. DEFINITIONS. Terms or phrases used in the SOP defined, as required, to insure understanding and correct interpretation.
7. TRANSPORTATION ORGANIZATION. Missions, organizations, and functions (unless published elsewhere) of the following:
 - a. Office of the transportation officer.
 - (1) Transportation officer.
 - (2) Deputy transportation officer or executive officer.
 - (3) Staff sections.
 - (4) Liaison officers: United States Air Force, Military Sea Transportation Service, Army, allied, and others.
 - b. Field installations.
 - (1) Water terminals.

- (2) Transportation supply depots.
- (3) Transfer points and other special transportation activities.
- (4) Transportation movements branch and other transportation organization.

8. ADMINISTRATION.

a. General. Application and implementation of command policies and directives.

b. Correspondence.

- (1) Types. Types; instructions for preparing, forwarding, and handling; paper economy measures.
- (2) Classified documents. Types of classification and authority to classify; handling, delivery, and receipting methods and procedures; security measures and responsibilities.

c. Personnel.

- (1) General. Application and implementation of command policies and directives.
- (2) Local civilian labor. Implementation of command policies and administrative procedures for procurement, utilization, and pay; application of provisions of Geneva Convention.
- (3) Prisoners of war. Implementation of command policies and administrative procedures for procurement as labor; utilization, treatment, and security; application of provisions of Geneva Convention.
- (4) Replacements. Responsibilities and procedures for requisitioning transportation replacements; implementation or elaboration of command policies and directives.

d. Reports. Types and number of administrative reports to be submitted; method and frequency of submissions (samples to be appended); application of reports control procedures.

9. INTELLIGENCE

a. General. Purpose and importance of transportation intelligence, transportation intelligence mission, types of intelligence, application of command directives (FM 55-8).

b. Collection of information. Collection agencies, essential elements of information, sources, coordination, collection plan, methods, reporting and disposition of captured enemy material for intelligence purposes.

c. Processing information. Responsibilities and procedures for recording, evaluating, and interpreting information.

d. Dissemination. Policies, methods, criteria, security classifications, transmissions, time considerations.

e. Usage. General application of intelligence to transportation operations and planning; precautions against enemy counterintelligence.

f. Counterintelligence. Objectives, responsibilities, and application to the transportation service.

g. Reconnaissance. Purpose and responsibilities.

10. PLANS

a. Transportation requirements. Responsibilities for maintaining current lists of transportation requirements for movement of the unit or its elements by rail, truck, inland waterway, and air.

b. Transport availability. Responsibilities for maintaining current lists of available transportation—organic, assigned, or attached to the unit, including local civilian transportation.

c. Entrucking plans. Responsibilities of subordinate units for maintaining current entrucking plans; designation of vehicles to transport personnel, supplies, and organizational equipment.

d. Traffic circulation plans. Statement that traffic circulation plans will be coordinated with traffic circulation plan of this headquarters.

e. Special operations. Statement that transportation aspects of subordinate troop plans for special operations (e.g., river crossing, pursuit, retrograde movement) will be coordinated with this headquarters.

f. Plans by units in reserve. Statement that plans by these units for forward or lateral movement will be coordinated with this headquarters.

g. Pooling organizational transportation. Procedures, including availability reports, unit responsibilities for furnishing commissioned and non-commissioned officers, maintenance of equipment, and administrative support of personnel.

h. Civil aid. Statement that services and subordinate units will submit plans in advance for movement of civilians and civil aid supplies, but that plans will not be implemented without prior approval.

i. Main supply routes and supply and service installations. Responsibilities and procedures for maintaining up-to-date plans for recommending main supply routes and service installations.

11. TRAINING

a. Responsibilities and procedures for preparing and supervising training programs of transportation units.

b. Responsibilities and procedures for exercising technical supervision over transportation training throughout the command.

12. DEFENSE AND DISPERSION. Implementation of command policies and directives; responsibilities of corps transportation units for area of defense; defense against airborne, bacteriological, nuclear, and chemical attack; sabotage; and infiltration and guerrilla warfare; procedures for reporting enemy activity.

13. AMPHIBIOUS OPERATIONS

a. General. This SOP standardizes normal procedures in the preparation and execution of amphibious operations and will apply unless otherwise prescribed.

- (1) Subordinate units issue SOP to conform.
- (2) References.

b. Planning. Consideration must be given to the following:

- (1) Requirements of the tactical plan and the scheme of maneuver.
- (2) Availability of landing craft and ships by type, size, cargo, personnel capacity.
- (3) Establishing and maintaining close liaison with the Navy, the Air Force, and task-force commanders.
- (4) Landing force embarkation and tonnage and the breakdown of equipment and supplies as indicated in tables to be submitted by task-force commanders.
- (5) Arranging and coordinating through channels for training appropriate personnel in unit loading and embarkation.
- (6) Movement to the embarkation areas and delivery of equipment and supplies to include waterproofing, marking, and palletizing.
- (7) Supervision within the embarkation area.
- (8) Buildup period for supplies and ship turnaround time.
- (9) Alternate logistical procedures or an entire alternate plan to support alternate tactical plans being considered.

c. Movement to the staging area.

- (1) Warning orders.
- (2) Method of movement—rail, highway, air, water.
- (3) Control of movement.

d. Staging area.

- (1) Reception.
- (2) Spot delivery of equipment.

- (3) Control points to control flow of equipment and personnel to embarkation points or assembly areas.
- (4) Assembly areas for temporary storage of equipment and supplies to be loaded on transports.
- (5) Transportation to haul supplies and equipment from assembly areas to ships.
- (6) Areas where final waterproofing can be completed.
- (7) Facilities to prepare cargo not already processed for loading.
- e. *Embarkation of troops.*
 - (1) Movement to embarkation point or assembly areas.
 - (2) Control of movement to vessels.
- f. *Movement to objective area.* In accordance with naval directives.
- g. *Ship-to-shore movement.*
 - (1) Debarkation of equipment, supplies, and service troops at the proper time to support tactical operation.
 - (2) Control and landing of emergency supplies.
 - (3) Evacuation of casualties by water.
- h. *Beach organization.*
 - (1) Transportation unit reconnaissance party.
 - (2) Consolidation of supplies and transportation for subsequent logistical support of the landing force.
 - (3) Control.
 - (a) Vehicular traffic.
 - (b) Transfer operations (buildup area).
 - (4) Communication between beach organization and control vessel and ships.

14. INSPECTIONS

- a. Reference: SOP of higher headquarters relative to inspections.
- b. Purpose.
- c. Policy.
- d. Types of inspections: vehicle utilization, transportation training, quality of maintenance and maintenance support, efficiency of operations, records system.
- e. Frequency.
- f. Procedures before making an inspection.
- g. Procedures upon completing an inspection.
- h. Reports on findings, including a sample format, number of copies, and distribution.

15. AIRBORNE OPERATIONS. Implementation of command policies and directives in establishing responsibilities and procedures for transportation unit participation in airborne operations.

16. COMMUNICATIONS

- a. Communications net for coordination of transportation.
- b. Methods of ground-to-air contact to provide coordination with airdrops and land transportation.
- c. Cross-reference to communications-net diagram.

Commander (name and grade)

Annexes
Distribution
Authentication

6.6 Outline for Transportation Standing Operating Procedure for Units

STANDING OPERATING PROCEDURE

(Unit)

TABLE OF CONTENTS

Section I. GENERAL

1. APPLICATION. (Operations to which SOP applies.)
2. PURPOSE.
3. REFERENCES. (FM's, TM's, SOP's of higher headquarters, etc.)
4. RESPONSIBILITY FOR PREPARATION, CHANGES, REVISIONS.
5. EFFECTIVE DATE.

Section II. COMMAND, STAFF, LIAISON

6. ORGANIZATION
 - a. Normal.
 - b. Special internal attachments and organization.
 - c. Normal and special external attachments and support.
7. COMMAND POSTS
 - a. Normal location in relation to next higher headquarters.

b. Reporting change of location—coordinates and time.

c. Forward command posts.

(1) Situation for which required.

(2) How organized.

(3) Personnel and equipment.

8. STAFF DUTIES

a. Special or additional duties of staff officers.

b. Duties of special staff officers.

9. LIAISON.

a. Duties of liaison officers.

b. Responsibilities for liaison—higher, lower, and adjacent units.

10. PLANNING RESPONSIBILITY

Section III. ADMINISTRATION

11. GENERAL CHANNELS.

12. REPORTS.

a. Routine reports.

b. Special reports.

c. Submission.

(1) Title and reports-control symbol.

(2) Form of report.

(3) Date due.

(4) Number of copies.

(5) Negative report required or permissible.

13. PROMOTION POLICIES.

a. Officer.

b. Enlisted.

c. Battlefield.

14. COURTS-MARTIAL.

a. Location jurisdiction.

b. Procedure for submitting cases.

15. MAIL.

a. Handling of official mail.

b. Handling of personal mail.

16. LEAVES AND PASSES.

a. Policy of command—conduct, VD control.

b. Authority to grant.

17. JOURNALS AND HISTORY.

a. Responsibility for unit journal and history.

b. Maintenance of staff section journals.

18. DISTRIBUTION OF MILITARY PUBLICATIONS.

19. HANDLING OF PRISONERS OF WAR.

a. Reference to FM 19-40 and FM 27-10.

b. Special instructions for capturing unit.

20. AWARDS AND DECORATIONS.

a. Channels.

b. Form.

c. Presentation.

21. ORDERS (FM 101-5).

22. BILLETS AND BIVOUACS.

a. Policies—occupation and clearance.

b. Billeting party.

Section IV. MOVEMENT

23. GENERAL (SOP of higher headquarters).

24. MOTOR MOVEMENT (FM 25-10).

a. Preparation of vehicles.

b. Motor marches.

(1) Strip maps.

(2) Route reconnaissance.

(3) Messing and refueling.

(4) Night marches.

(5) Makeup of march units and serials.

(6) Distances to be maintained.

(7) Speed and rate of march.

(a) Rate of march for column.

(b) Speed of lead vehicle.

(c) Permissible speed to catch up.

(d) Time length of march unit or serial.

(8) Posting of traffic guards during halt.

c. Movement by infiltration.

d. Conduct of personnel during movement.

(1) Passengers.

(2) Drivers.

25. VEHICLE AND EQUIPMENT OPERATIONS.

a. Motor pool.

(1) Dispatch.

(2) Service.

(3) Maintenance.

b. Regulations for administrative vehicles.

26. RAIL MOVEMENTS.

a. Action by S1.

(1) Movement policy.

(2) Troop list.

(3) Transportation movements personnel.

b. Action by S2.

(1) Reconnaissance report.

(2) Security.

c. Action by S3.

(1) Determination of rolling stock required.

(2) Coordination of loading plan.

(3) Preparation of loading schedule and areas.

d. Action by S4.

(1) Initiation of transportation request.

(2) Provision for troop and guard mess.

(3) Procurement of blocking and dunnage.

(4) Preparation of shipping documents.

27. AIR MOVEMENT.

- a. Action by S1.
- b. Action by S2.
- c. Action by S3.
 - (1) Determination of craft required.
 - (2) Coordination of loading plan.
 - (3) Preparation of loading schedule and areas.
 - (4) Explanation of air-transportability technique.
- d. Action by S4.
 - (1) Initiation of transportation request.
 - (2) Determination of availability of tiedown devices or material.
 - (3) Preparation of weight-of-equipment data for loading computation.

- (4) Preparation of shipping documents.
- (5) Determination of quantity and types of vehicles required to load and unload aircraft.

28. WATER MOVEMENT.

- a. Action by S1.
- b. Action by S2.
- c. Action by S3.
 - (1) Determination of shipping required.
 - (2) Coordination of loading plan.
 - (3) Preparation of loading schedule and areas.
- d. Action by S4.
 - (1) Initiation of transportation request.
 - (2) Provision for troop mess.
 - (3) Preparation of shipping documents.

Section V. SECURITY

29. GENERAL: POLICIES AND RESPONSIBILITIES.

30. SECURITY DURING MOVEMENT.

- a. Air guards.
- b. Manning of vehicular weapons.
- c. Camouflage during halts.
- d. Advance, flank, and rear guards.
- e. Action to be taken in case of attack.
 - (1) Air.
 - (2) Mechanized.
 - (3) Troops and guerrillas.
 - (4) Nuclear, bacteriological, chemical.

31. SECURITY IN BIVOUAC.

- a. Camouflage.
- b. Mines and boobytraps.
- c. Placement of weapons in case of attack.
 - (1) Air.
 - (2) Mechanized.
 - (3) Troops and guerrillas.

- (4) Nuclear, bacteriological, chemical.
- d. Joint security.
- e. Security plans.
- f. Sentry posts and outposts.

32. ATTACK WARNING SIGNALS.

- a. Air.
- b. Airborne.
- c. Mechanized.
- d. Troops and guerrillas.
- e. Nuclear, bacteriological, chemical.

33. FIRE SAFETY AND FIRE FIGHTING.

- a. Plans.
- b. Fire personnel and duties.
- c. Safety rules (motor pool, kitchen, etc.).

34. ALERT PLANS.

- a. Unit plan.
- b. Alert roster.
- c. Armament and equipment.
- d. Phase system for alert warnings.

35. DESTRUCTION OF EQUIPMENT.

Section VI. COMMUNICATIONS

36. TYPES USED.

37. COMMUNICATION BETWEEN UNITS.

- a. Radio net.
- b. Telephone system.
- c. Teletypewriter system.
- d. Responsibility for installation.

38. COMMUNICATION PROCEDURE.

- a. Radiotelephone voice and radioteletype procedure.

- b. Visual, sound, messenger procedure.
- c. Communications security.
- d. Citation of SOI and SSI of higher headquarters.

39. SIGNAL MAINTENANCE RESPONSIBILITY.

- a. Commander.
- b. Communications officer.
- c. Users and operators.

Section VII. RECONNAISSANCE, INTELLIGENCE, AND COUNTERINTELLIGENCE

40. RECONNAISSANCE. Essential elements of information.

41. COMBAT INTELLIGENCE.

- a. Definition of "spot reports."
- b. "Spot reports" required:
 - (1) Initial contact with enemy.

- (2) Marked change in enemy disposition or situation.
- (3) Attack by armored, air, or airborne forces.
- (4) New units identified.
- (5) Enemy strength, composition, and movement.
- (6) Location of enemy installations.
- (7) Use of chemicals or new weapons.
- (8) New materials or equipment.

42. COUNTERINTELLIGENCE.

- a. Mail censorship.
- b. Blackout discipline.
- c. Information to be given if captured.
- d. Signs and countersigns.
- e. Destruction of classified documents.
- f. Civilian control.
- g. Secrecy discipline.
- h. Information to press representatives.

Section VIII. SUPPLY AND MAINTENANCE

43. CLASS I SUPPLY.

- a. Ration pickup.
- b. Daily ration return and ration cycle.
- c. Reserve rations carried.
 - (1) By unit.
 - (2) By individual.
- d. Responsibility for attached units.

44. WATER.

- a. Authorized source.
- b. Purification by expedient methods.
- c. Water economy.

45. CLASS II AND IV SUPPLY.

- a. Requisition days for various services.
- b. Pickup procedure.
- c. Salvage turn-in procedure.
- d. Droppage by battle-loss certificate.

46. CLASS III SUPPLY.

- a. Resupply.
- b. Fuel reserve.

47. CLASS IIIA SUPPLY.

- a. Resupply.
- b. Fuel reserve.

48. CLASS V SUPPLY.

- a. Method of requisitioning.
- b. Forms used and certificates required.
- c. Basic load.
- d. Salvage.

49. MAINTENANCE OF VEHICLES AND EQUIPMENT.

- a. Echelon of maintenance.
- b. Responsibility of maintenance officer.
- c. Forms used.
- d. Priorities.

50. REPAIR PARTS.

- a. Method of requisitioning.
- b. Maintenance of stock levels.
- c. Inspections of maintenance and levels.
- d. Parts and equipment record.

51. EVACUATION CHANNELS FOR VEHICLES AND EQUIPMENT.

By order of _____

Adjutant (name and grade)

Annexes. (May include Wearing of the Uniform, Reports Formats, Destruction of Classified Documents, Duties of Staff Officers, Staff Section SOP's, Loading Plans, Alert Plan, etc.).

Distribution
Authentication

6.7 Division Embarkation Order

Issuing unit
Place of issue (may be in code)
Hour and date of issue

File No. _____

Embarkation Plan No. _____

Maps: (Those needed for understanding the plan.)

References: (SOP's, operation order, administrative order, and other relevant material.)

1. ORGANIZATION FOR EMBARKATION.

a. Troop list for each embarkation group. (May be issued in form of annex.)

b. Assignment of each embarkation group to shipping, schedule showing berthing of ships, date and hour loading will begin, and date and hour embarkation will be completed by each embarkation group; other information pertinent to the embarkation group; other information pertinent to the embarkation schedule may be included. (May be issued in form of annex.)

c. Advance parties.

- (1) Composition.
- (2) Functions.
- (3) Movement to embarkation point. (Reference to SOP if applicable.)

2. SUPPLIES AND EQUIPMENT TO BE EMBARKED.

a. Amounts and types of supplies and equipment to be embarked.

b. Preparation of supplies and equipment for embarkation. Reference may be made to appropriate SOP.

c. Allocation of division supplies and equipment to cargo assembly areas. (May be issued in form of annex with appendixes.)

3. EMBARKATION POINTS AND CARGO ASSEMBLY AREAS.

a. Assignment of embarkation points and cargo assembly areas for loading. (May be in the form of a map, sketch, or overlay, and issued as an annex.)

b. Preparation of embarkation points and cargo assembly areas for loading; construction or improvement of exits and facilities in the embarkation area.

c. Assignment of mechanical loading devices, such as forklift trucks, cranes, roller conveyors, warehouse pallets, etc.

4. CONTROL.

a. Establishment and functions of embarkation control office. (Functions may be covered in SOP.)

b. Traffic circulation and control system in embarkation area and between embarkation area and base camp.

c. Establishment of security posts for prevention of fire, sabotage, and pilferage in cargo assembly and deck areas.

d. Communications for embarkation. (References may be made to SOI.)

5. MOVEMENT AND EMBARKATION OF PERSONNEL.

a. Schedule and method of movement from base camp.

b. Schedule and instruction for embarkation.

6. MISCELLANEOUS.

a. Embarkation responsibilities and tasks. Responsibility of embarkation group commanders and tasks of officers, such as supply officer, motor transport officer, unit loading officer, etc.

b. Special loading instructions. Stowage of certain types of cargo, handling of fragile or dangerous items, etc.

c. Miscellaneous instructions not covered elsewhere.

ACKNOWLEDGMENT INSTRUCTIONS

By Command of Major General _____

s/Colonel, U. S.
Chief of Staff

Annexes:

ALPHA—Organization of Embarkation Groups—Assignment of Shipping.

BRAVO—Loading Schedule.

CHARLIE—Supplies and Equipment to be Embarked.

DELTA—Embarkation Points and Cargo Assembly Areas. (Others as necessary.)

DISTRIBUTION:

OFFICIAL _____

s/Lt Col, U. S. ACofS, G4

Section II. INTELLIGENCE

6.8 Transportation Intelligence

Transportation intelligence is the product resulting from the collection, evaluation, interpretation, analysis, and integration of all available information about air, land, and water transportation systems which are of immediate or potential military significance. Intelligence includes data on the characteristics, condition, development, organization, materiel, operation, maintenance, and construction of transportation systems and facilities. These data are essential to strategic, logistical, and tactical planning. Formats for recording and reporting transportation information and intelligence are shown in FM 55-8.

6.9 Transportation Intelligence Estimate

a. *General.* Transportation intelligence esti-

mates are studies that describe, discuss, and apply interpreted data that, directly or indirectly, concern the transportation mission. These estimates are used by commanders in making sound and timely decisions and are part of the overall transportation estimate used to formulate the transportation plan. Since intelligence estimates are made after all available information has been collected and processed, they must be kept current by revision when new or additional information is received and processed. Estimates must be disseminated to appropriate planners in sufficient time to be useful. If there is not enough time for making and publishing of formal transportation plans, intelligence estimates may be disseminated directly to the ultimate users—the operating units.

b. *Elements considered.* An estimate does not

necessarily contain all of the elements listed below; content depends upon the transportation mission.

- (1) Statement of the transportation mission.
- (2) Characteristics of the area of operations and how they will affect this mission.
 - (a) Weather and climate: temperatures, wind conditions, rainfall, tide and river conditions, and a complete aeronautical weather forecast.
 - (b) Terrain features: critical terrain features, any obstacles known or suspected, soil trafficability, offshore gradient of beaches, surf, etc.
 - (c) Road and rail nets, including traffic bottlenecks: available lines of communication, capacity, condition, damage, repair work necessary.
 - (d) Bridges and tunnels: possible bottlenecks, such as bridges, tunnels, ruling grades, etc.
 - (e) Port and beach facilities and wharves.
 - (f) Airfields and other aircraft facilities.
 - (g) Inland waterways, locks, ports.
 - (h) Warehouses and other storage facilities.
- (3) Characteristics of enemy transportation equipment.

- (a) Locomotive characteristics and inventory.
- (b) Freight and passenger equipment characteristics and inventory.
- (c) Vehicle characteristics and inventory.
- (d) Crane data.
- (e) Waterway craft (inland waterway and oceangoing) characteristics and inventory.
- (f) Aircraft characteristics and inventory.
- (4) Transport capability of the enemy: air, water, motor, rail, miscellaneous. Include the enemy's capabilities to attack, defend, delay, withdraw, and reinforce, and probable areas involved, strengths, etc. Indicate how the transportation mission could be affected by each capability of the enemy, including such items as lines of communication apt to be lost or gained through enemy's use of each capability and increase or decrease in tonnage capability. (This could be done in an annex which lists probable effect of each capability on each mode.)
- (5) Conclusions, including effect of the intelligence estimate on U. S. and friendly forces.

Section III. TRANSPORTATION ESTIMATE AND PLAN

6.10 Transportation Estimate

TRANSPORTATION ESTIMATE

Transportation Section (Unit)
(Location)
(Date-time group)

Maps: (Sheet name, number, scale, and unit of measure series.)

1. **MISSION.** Mission of the command and of the transportation units in support of the tactical and logistical mission of the command. (May be obtained from orders from a higher headquarters or deduced from instructions or knowledge of the situation and may be expressed in terms of personnel and/or tons of cargo to be transported, discharged, and/or outloaded.)
2. **THE SITUATION AND CONSIDERATIONS.**

a. Intelligence situation. Refer to pertinent intelligence estimate.

b. Tactical situation.

- (1) Refer to current operation order.
- (2) Present and planned disposition of major friendly tactical elements, with emphasis on those units defending lines of communication or transportation units and operations; effect of planned troop moves on transportation operations.
- (3) All possible courses of action open to the command to accomplish the assigned mission.
- (4) Concept of projected operations once the immediate mission is accomplished.

c. Logistical situation.

- (1) Refer to current administrative order or overlay.
- (2) Status of supplies and equipment in all transportation organizations of the command, highlighting any inadequacies.
- (3) Any projected developments likely to affect the ability of transportation units to perform their mission from the logistical standpoint.

- (4) Status of supplies and equipment in other technical service units to be employed in logistical support of transportation operations which might adversely affect accomplishment of the mission.
- (5) All possible logistical courses of action, and the affects of each on possible friendly tactical courses of action.

d. Personnel situation.

- (1) Refer to current administrative order or overlay.
- (2) Status of personnel in all transportation units, including state of morale and any other considerations likely to have a bearing on their performance.
- (3) Status of personnel in other technical service units to be employed in logistical support of transportation operations which might adversely affect accomplishment of mission.

e. Assumptions. Logical assumptions may be made when a sufficient amount of factual information is not available for the preparation of the estimate.

f. Transportation situation. All known information, as detailed as possible, on each mode of transportation activity.

- (1) *Transportation situation by modes.* The format shown in (a) below should be modified as required for (b) through (k).

(a) Rail. Tabulate as shown.

Unit	Location	Strength Actual— Auth	Facilities Actual— Required	Equipment Lacking	Capability Actual— Potential
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- (b) Motor.
- (c) Inland waterway.
- (d) Air.
- (e) Water.
- (f) Transportation movements.
- (g) Staging areas.
- (h) Transportation depots.
- (i) Transportation technical intelligence units.
- (j) Pipelines (even though not operated by transportation units.)
- (k) Troop carrier space.
- (2) *Transportation units courses of action.* All courses of action open to transportation units for each possible logistical course of action set forth in c(5) above.

g. Special factors. Any other factors which might influence the choice of a course of action or the ability to perform mission, both from the

transportation standpoint and from the overall view of the mission.

3. ANALYSIS. Statement and analysis of the effects of each logistical course of action listed in paragraph 2c(5) on each mode of transportation.

a. Course of action.

Mode of activity*	Effect on personnel	Effect on equipment	Effect on facilities	Effect on capabilities
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b. Alternate course of action. Outline of alternate course(s) of action, if possible.

4. COMPARISON.

a. Dominant transportation factors and modes most likely to be used.

b. A comparison, based on the information in paragraph 3, of the various logistical courses of action, including their effects on each mode and their capabilities thereof. (Through this weighing of advantages and disadvantages, the most favorable course of action from the transportation standpoint can be determined.)

c. Feasibility of the use of the various lines of communication, ports, and beaches in comparison with enemy capabilities, weather, terrain, etc.

5. CONCLUSIONS.

a. Statement indicating whether the mission (par. 1) can be accomplished from the standpoint of transportation support.

b. Statement indicating which of the possible logistical courses of action can best be supported from the transportation standpoint.

c. Statement calling attention to any considerations required should alternate courses of action be chosen.

- (1) Number and type of transportation units required over and above those available for each course of action if mission cannot be supported.
- (2) Personnel and/or equipment shortages in existing units which would prevent accomplishment of mission.
- (3) Any repairs or construction work essential to successful accomplishment of the mission from the transportation standpoint.
- (4) Any other transportation considerations which should be brought to the attention of the commander.

/s/ _____
Transportation Officer
(name and grade)

Annexes
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* Same modes of activity as 2f(1).

6.11 Transportation Plan

(Any of the paragraphs and subparagraphs below may consist wholly, or in part, of references to the appropriate annexes, and the annexes in turn may be amplified by properly referenced appendixes. Each transportation mode should have a separate annex.)

TRANSPORTATION PLAN _____
(Number)

Transportation Section (Unit)

(Location)

(Date-time group)

Maps and references: Sheet name, number, scale, and unit of measure, series shown for each map. Other references include city plans, navigation charts, other plans bearing on the transportation plan, etc.

Task organization: Annex A, Task Organization.

1. SITUATION.

a. Enemy forces. All capabilities of the enemy to hinder, disrupt, or otherwise affect the operations of the transportation units and other elements of the command, including such items as damage to lines of communications, use of mass destruction weapons, etc. (Annex B, Intelligence.)

b. Friendly forces. Units to be supported, location and strength, with emphasis on those units engaged in protection of lines of communication and transportation units or activities, including higher, adjacent, and supporting units of both U. S. and allied forces.

c. Characteristics of the area of operations.

(1) *Weather.* Temperatures, wind conditions, rainfall, tide and river conditions, aeronautical weather information, etc.

(2) *Terrain and hydrography.* Critical terrain features, soil trafficability, beach gradients, any known obstacles, and possible effect on the transportation modes.

(3) *Lines of communication.* All lines of communication and physical condition.

d. Attachments and detachments.

e. Assumptions and policies. Any pertinent policies and logical assumptions needed in preparing the plan; for example, proposed locations of major unit boundaries, troop strengths to be supported in different phases of the operation, etc.

2. MISSION. Mission of transportation units in support of the command.

3. EXECUTION.

a. Concept of operation. The transportation officer's overall concept of the operation, including probable increases in supported units, additional territory to be supported, etc. (Annex C, Concept of Operations.)

b. Rail. Specific tasks assigned rail units. (Projected loads, schedules, facilities, lines of communication, etc., are best submitted in the form of an annex to the plan.)

c. Motor.

d. Air.

e. Water.

f. Inland waterway.

g. Transportation movements.

h. Staging areas.

i. Transportation depots.

j. Pipelines (even though not operated by transportation units).

k. Troop carrier space. Proposed use of air capacity allocated to the command although transportation organizations do not assign tasks. (As indicated in *b* above, similar information for each mode of transportation is best submitted in the form of an annex to the plan, the format of which should parallel that of the plan itself so far as practical.)

l. Coordinating instructions.

(1) *Defense and security.* Reference to appropriate SOP or defense plan.

(a) Individual.

(b) Facilities.

(c) Lines of communication.

(d) Shipments.

(e) Censorship.

(f) Communications.

(2) *Counterintelligence.* Annex B, Intelligence.

(3) *Technical intelligence.* Annex B, Intelligence.

(4) Effective time and date.

4. ADMINISTRATION AND LOGISTICS.

a. Administration.

(1) *Policies.* Reference to paragraph 1c.

(2) *Procedures.* SOP's and related guides of higher headquarters not covered elsewhere in the plan.

(3) *Required reports.*

b. Logistics.

(1) *Transportation supply.* The following times are covered by reference to current SOP's when applicable.

- (a) Levels of supply.
- (b) Replacement factors and consumption rates.
- (c) Requisition procedures and cycles.
- (d) Emergency requisition procedures.
- (e) Local procurement.
- (f) Controlled items.
- (g) Surplus material.
- (h) Captured material.
- (i) Salvage and scrap.
- (j) Interservice supply.
- (k) Class IV equipment.
- (l) Equipment out of commission for parts procedures.

(2) *Supply support of transportation mission by other services.*

(3) *Transportation maintenance.* Maintenance facilities, indicated by mode, shop locations, and responsibilities of each maintenance unit.

c. Personnel.

(1) *Policies.*

- (a) Use of local civilian personnel.
- (b) Use of prisoners of war.
- (c) Use of U. S. civilian personnel.

(2) *Strengths.*

(3) *Replacements.*

(4) *Procedures.*

5. COMMAND AND SIGNAL.

a. Annex—Signal.

b. Command.

- (1) Location of CP's of major commands.
- (2) Locations of transportation movements branches.

ACKNOWLEDGEMENT INSTRUCTIONS.

Commander (name and grade)

Annexes

Distribution

Authentication

6.12 Feasibility Test for Transportation Plan

1. GENERAL.

a. This test is prepared to enable transportation staff planners to check the feasibility of a transportation plan (annex to administrative orders, letter of instructions, etc.) after the plan has been prepared.

b. The test has been prepared in checklist form. Paragraph 2 gives general considerations which apply to all modes of transportation, and the remaining paragraphs lists items which apply to a specific mode. Some items which appear in the

remaining paragraphs may seem to belong under the general paragraph; however, these items represent abnormal conditions which may have a drastic effect on that mode.

c. In using the checklist, consider the items listed in paragraph 2 for each mode in addition to the paragraph that applies to that mode.

2. GENERAL CHECKLIST ITEMS.

a. Calculated risks. Calculated risks involved. Effect on the mission. Governing factors.

b. Weather and terrain. General considerations. Favorable or adverse effect on the mission.

c. Enemy action. Consideration of enemy guerrilla action, clandestine action, etc.

d. Political and economic situation. Interference with local economy. Friendly or unfriendly attitude of the civil population.

e. Transportation net. Integration of elements of the transportation net. Portions of the net reserved for civilian use. Emergency procedures for joint civil-military use. Engineer construction service support of the present net and future operations.

f. Allocation and utilization of modes. Optimum utilization of transport capacity. Utilization of supporting services' capacities. Allocation to modes of tasks commensurate with their capabilities and equipment. Adequate provisions for retrograde cargo.

g. Logistical support of operations. Support of modes in sufficient quantity and time to accomplish the mission; e.g., POL products, repair parts, etc.

h. Task organization.

(1) Clear definition of command relationships, missions, and functions.

(2) Troop list assignments consider:

- (a) Strength.
- (b) Training.
- (c) Morale.
- (d) Available transport equipment.

i. Local civilian and prisoner-of-war labor. Availability of civilian and prisoner-of-war labor in the skills required. Requirement for mobile civilian labor units for phase II and III operation. Adequate administrative and logistical support.

3. MOTOR TRANSPORT.

a. Requirements versus capabilities.

b. Traffic circulation plan:

- (1) Road net supports planned traffic.
- (2) Requirement for additional highway regulation personnel.

- (3) Adequate road repair and road maintenance support.
- (4) A designation of routes (restricted, dispatch, etc.
- (5) Possible joint use of road net; i.e., can both combat forces (U. S. and/or allied forces) and civilian traffic use it simultaneously?
- (6) Availability of hardstand, maintenance areas, truck parks, relay stations, transfer points.
- (7) Marked routes, availability of marking signs.

4. RAIL.

- a. Requirements versus capabilities.
- b. Unusual weather or terrain factors:
 - (1) Are heavy rains due that may cause washouts, floods, or landslides?
 - (2) Is extreme subfreezing weather due?
- c. Engineer maintenance and construction support for rehabilitation or for major repair of rail line.
- d. Yards, roundhouse, repair shops.
- e. Suitable water and fuel supplies (if steam locomotives are to be used).
- f. Limiting factors:
 - (1) Bridge, weight, and clearance.
 - (2) Tunnel clearance.
 - (3) Roadbed and trackage.
 - (4) Rolling stock—condition, power, gage.
 - (5) Locomotives—condition, power, gage.
 - (6) Train operations communications.

5. INLAND WATERWAY.

- a. Check requirements versus capabilities.
- b. Weather and terrain. Freezeup or flood periods, tidal ranges, currents, fogs.
- c. Obstructions. Low bridges, types of drawbridges. Natural obstructions such as heavy weeds that might foul propellers.
- d. Locks. Locks controlled by assigned permanent personnel or the individual inland-waterway craft. Size of locks, time to pass through.
- e. Channels. Required maintenance. Size, depth, and width.
- f. Navigational aids. Sufficient fixed or mobile navigational aids for full utilization, day and night.
- g. Requirement for intermediate transfers.
- h. Condition of available craft.
- i. Marine inland-waterway repair and maintenance support.
- j. Inland-waterway facilities, docks, cranes.

6. PORTS AND BEACHES.

- a. Check requirements versus capabilities.
- b. Port facilities:
 - (1) Floating cranes for heavy lifts.
 - (2) Piers, docks, warehouses, open ground areas.
 - (3) Road and rail nets.
 - (4) Navigational aids.
 - (5) Protected anchorage areas.
 - (6) Utilities (electricity, etc.).
 - (7) Harbor craft.
 - (8) Berth space, lengths, and depths.
- c. Beach facilities:
 - (1) Anchorage areas.
 - (2) Routes of ingress and egress.
 - (3) Road and rail nets.
 - (4) Hardstand and open ground areas.
 - (5) Equipment (forklifts, cranes, etc.).
- d. Weather and terrain:
 - (1) Ports:
 - (a) Tides and currents.
 - (b) Underwater obstructions.
 - (2) Beaches:
 - (a) Tides, currents, surf, gradient, tidal range.
 - (b) Underwater obstructions.

7. TRANSPORTATION MOVEMENTS.

- a. Sufficient teams accomplish transportation movements mission.
- b. Adequacy of transportation movements plan to accomplish the mission. Flexibility or rigidity.
- c. Location of teams located for maximum utilization.
- d. Establishment of documentation procedures insure accomplishment of mission.

8. STAGING AREAS.

- a. Capability of processing planned workloads.
- b. Adequate facilities.

9. TRANSPORTATION DEPOTS.

- a. Ability to support the mission.
- b. Adequate facilities.

10. AIR.

- a. Check requirements versus capabilities.
- b. Marginal weather:
 - (1) Low ceilings.
 - (2) Low visibility.
 - (3) Ice conditions (on ground) determining maintenance and time required to melt, plus closed hangar area.
 - (4) Temperatures to be encountered.
- c. Terrain: Altitudes to be encountered (temperature and altitudes affect lift capabilities).

- d.* Navigational aids:
 - (1) Possibility of day and night operations.
 - (2) Ground stations:
 - (a) Ground controlled approach (GCA).
 - (b) Radio range.
 - (c) Instrument landing systems.
 - (d) Omnidirectional range (Omni range).
 - (e) Radar plotting station.
 - (3) Airborne navigational equipment.
 - e.* Communications: Adequacy of unit communications, augmentation required.
 - f.* Restrictions to flight:
 - (1) Maintenance of established air routes, including consideration of fire lanes.
 - (2) Degree of air superiority.
 - (3) Arrangements for weather reports from Air Force.
 - g.* Adequacy and location of landing sites or airfields, plus facilities at such locations.
 - h.* Maintenance:
 - (1) Condition of aircraft (number of hours previous operation).
 - (2) Maintenance units available.
 - (3) Repair parts available.
 - (4) Location and stock of depot support.
 - i.* Degree of training of supported units in use of logistical air support.
11. FLEXIBILITY.
- a.* Provision for rerouting or diversion.
 - b.* Interchange points.
 - c.* Transfer points.
 - d.* Substitution of one mode for another.
 - e.* Capability of handling emergency transportation tasks.

CHAPTER 7

MISCELLANEOUS

Section I. CAPABILITIES OF TRANSPORTATION MEDIUMS

7.1 Tonnage Requirements and Transportation Capabilities

For methods used to determine tonnage requirements, see FM 101-10. The figures given below are approximate and are to be used as guides only.

Medium	Tons per day ST ¹ LT		Adequate to maintain
Highway: ¹			
Gravel.....	1,600	1,430	1 division
Medium condition..	3,600	3,220	3 divisions
First-class.....	10,000	8,900	7 divisions
Railway, each way:			
Single track.....	4,000	3,570	3 divisions
Double track.....	12,000	10,700	9 divisions
Gasoline pipeline: ²			
6-inch.....	2,000	1,790	5 to 8 divisions
4-inch.....	930	830	3 divisions
Water terminal discharge rate: ³			
Average cargo ship..	720	643	½ division
Across beach:			
Per 1,000 yards of beach.....	1,680	1,500	1 division plus

7.2 Animals

a. Dogs.

- (1) Trained dogs may be used individually or in teams to transport cargo in arctic and subarctic areas. They also have limited use in temperate zones to carry messages and small packages of mail, usually in regions inaccessible to other means of transport. Dogs should be permitted to rest 10 minutes in each hour and should not be worked continuously for more than 16 hours per day. For planning purposes, towed loads should not exceed 100 pounds per dog although the heavier breeds are capable of loads of 200 pounds per dog on a flat surface with good traction. The dog most commonly

used in the arctic and subarctic is the Eskimo or husky. The German shepherd is usually used in temperate zones. The figures below are for normal operating conditions and vary widely under extremes of weather and terrain.

- (2) On packed snow with good traction, an individual dog in a sled team has the following cargo-carrying capabilities. On soft snow, load and speed must be reduced 50 percent.

	Pounds of load per dog ¹	Distance in hour ² Km miles	
Flat.....	50	9.6	6
Hilly.....	50	4.8	3
Mountainous.....	50	1.6	1

- (3) On hard surfaces with good traction, an individual dog has the following capabilities for carrying cargo packs, messages, and mail.

Terrain	Pounds of load per dog		Distance in hour			
	Cargo pack	Messages or mail	Cargo pack		Messages or mail	
			Km	Mi	Km	Mi
Flat.....	35	5 percent	3.2	2	24	15
Hilly.....	30	of dog's	3.2	2	16	10
Mountainous..	25	weight	1.6	1	8	5

b. Pack Mules.

- (1) Height: 59 to 62 inches.
- (2) Weight: 1,000 to 1,200 pounds.
- (3) Rate of march: 3.5 to 4 miles (5.6 to 6.4 kilometers) per hour.
- (4) Capacity: 200 to 250 pounds.
- (5) Movement of casualties: 1 litter or 2 sitting casualties.
- (6) Forage: 10 pounds of oats and 14 pounds of hay per day. May be reduced for short periods up to 10 days without impairing capacity.
- (7) Water: 10 gallons per day.
- (8) Noneffective rate: 3.2 percent.

¹ Daily forward tonnage, assuming sustained operations, adequate road maintenance, and two-way traffic.

² The capacities of pipeline systems vary, depending on the size of pipe, gradient, location, and size of pumps, and type of construction. Welded commercial pipelines can be operated at much greater pressures than standard military lines which have flexible couplings.

³ Water terminal discharge rate of 1,440 ST per day required to adequately maintain 1 division alicee. See also paragraph 5.2b.

¹ Includes weight of sled.

² Reduce 50 percent when load is doubled.

(9) Average daily distance:

- (a) Mountainous terrain—12 miles (19 kilometers).
- (b) Rolling or flat terrain—24 miles (39 kilometers).

(10) Gradeability:

- (a) Rate of ascent—1,650 vertical feet (503 meters) per hour.
- (b) Rate of descent—1,000 vertical feet (305 meters) per hour.

c. Transportability.

Vehicle	Capacity (horses of mules)
Trailer, 2-horse van.....	2
Truck, 1½-ton, cargo.....	2
Truck, 2½-ton, cargo.....	4
Semitrailer, 6-ton, combination animal and cargo.....	8
Railroad stock car, 40-foot.....	25, approximately
Railroad stock car, 36-foot.....	20 to 22, approximately
Airplane, cargo transport.....	4 to 6*

d. Horse-Drawn Carts. Capable of traveling 20 miles (32 kilometers) per day drawing a payload of 1,000 pounds.

7.3 Human Bearers

For planning purposes, the following may be assumed:

* May be transported at altitudes up to 18,000 feet with no ill effects.

a. Average Cargo Loads.

- (1) Male bearer—80 pounds.
- (2) Female bearer—30 to 35 pounds.

b. Personnel Loads. 8 to 12 bearers per liter team.

c. Rate of March. For average conditions on level terrain—12 miles per day. To estimate the time needed to cover a given distance in hilly or mountainous areas, use the following relationship. For these conditions, cargo loads shown in a above should be reduced from 20 to 30 percent, depending upon steepness of the terrain.

$$T = t + a + d$$

where:

T = total time required

t = time required to march a given map distance

a = $\frac{\text{total ascent in feet during march}}{1,000}$

d = $\frac{\text{total descent in feet during march}}{1,500}$

d. Overloading and Speed-Up. Overloading and speeding up operations increase the sick rate and cause desertion.

e. Noneffective Rate. Approximately 30 percent.

f. Supervision. Close supervision is required to prevent pilferage.

Section II. DIMENSIONS AND WEIGHT DATA

7.4 Transportation Unit Equipment

Listed below are some of the principal items of unit equipment pertaining to one or more types of transportation units. This information, when applied to authorized quantities of the listed items,

aids planners and operators in the formulation of loading plans. When preparing the loading plan, this information should be used in conjunction with configuration data and equipment characteristics to be found elsewhere in the manual.

Item (uncrated unless otherwise noted)	Length (in.)	Width (in.)	Height (in.)	Cu. ft.	Weight (lb.)
CHEMICAL:					
Breathing apar, oxygen-generating.				2.2	40
Kit, chemical agent detector.....				0.2	4
Mask, protective, field.....				0.47	4.1
Respirator, paint spray.....				0.5	0.4
Tool set, gas-mask rep.....				0.1	4
ENGINEER:					
Adapters, piledriver lead, for crane shovel, 10T.....				1.46	175
Backhoe for crane shovel, 10T.....				417	6,400
Book set, celestial navigation.....				.72	29
Boom for crane shovel, 10T, 35-ft.....	420			319	2,450
Breaker, paving, pneu, 80 psi, 1¼ × 6 in. chuck.....				3.17	112

Item (uncrated unless otherwise noted)	Length (in.)	Width (in.)	Height (in.)	Cu. ft.	Weight (lb.)
ENGINEER—Continued					
Bucket, clamshell, $\frac{3}{4}$ cu yd				585	4,850
Bucket, dragline, $\frac{3}{4}$ cu yd				210	6,125
Carpenter set No. 1 engr sqd				17	330
Carpenter equip set No. 3 engr plat				8	230
Carpenter equip set No. 2 engr	38	24	11	5.8	132
Compressor, air, gas, 105 cfm, skid- mtd	120	90	74	463	6,605
Compressor, air, set No. 1, 55 cfm, airborne	60	48	39	65	1,358
Compressor, air, tlr-mtd, 315 cfm	180	84	84	735	12,000
Compressor, tlr-mtd, 500 cfm, diesel	184	85	98	940	14,400
Crane, revolving, tractor-mtd, 7,500-lb, 35-ft boom				1,395	9,785
Crane, shovel, crawler, 10T, gaso- line, $\frac{3}{4}$ cu yd	137	116		1,760	44,000
Crane, shovel, trk-mtd, 20T, $\frac{3}{4}$ cu yd, gasoline	387	108	138	3,350	54,000
Crane, shovel, crawler, 40T, 2 cu yd, diesel	196	147		3,619	85,000
Crane, tractor, wheeled, 40,000-lb, 20-ft boom				3,045	48,000
Diving equip, 2 persons, 200-ft depth				234	8,219
Diving equip, 2 persons, 100-ft depth	48	30	36	29	711
Drafting set, GP				13	225
Drill, pneu, ptbl, rock, 55 psi, 1 $\times$ 4 $\frac{1}{4}$ -in. hex chuck				2	42
Drill, pneu, ptbl, rotary, steel, No. 3 Morse taper, 1 $\frac{1}{4}$ in. cap				3.75	115
Drill, ptbl, rotary steel, No. 3 Morse taper, 1 $\frac{1}{4}$ -in. cap					28
Extinguisher, fire, CO ₂ , 15-lb cap				2.8	71
Extinguisher, fire, CO ₂ , wheeled, 50-lb cap				27	385
Fire and salvage equip set, marine				2,630	45,000
Floodlighting set No. 2, ptbl				126	1,900
Generator, gas, skid-mtd, 1.5-kw					114
Generator, ptbl, gas, skid-mtd, 5-kw					1,300
Generator, ptbl, skid-mtd, diesel, 15-kw	84	30	54	73	3,455
Generator, ptbl, skid-mtd, diesel, 30-kw	108	36	69	156	5,000
Grinder, ptbl, rotary, 8 $\times$ 1-in. wheel	15	12	15	1.5	90
Hoist, chain, 3T				1.09	48.5
Lamp, elec, ptbl, CP, set No. 1	31	20	16	5.8	180
Light set, gen illum, 25-outlet				53.1	880
Light set, gen illum, 15-kw				240	5,950
Lubricator, mtd on M105E3 tlr	147	69	69	405	3,150
Metalizing set				23	650
Pioneer equip set, engr plat				221	2,705
Pioneer equip set, engr sqd				26	752
Power control unit, cable, 1 drum, front mounting, 12,000- to 17,000-lb DBP				23.4	1,430

See footnotes at end of table.

Item (uncrated unless otherwise noted)	Length (in.)	Width (in.)	Height (in.)	Cu. ft.	Weight (lb.)
ENGINEER—Continued					
Pump, centrifugal, gas, 55 gpm, 50-ft head				14.2	250
Pump, centrifugal, gas, 2-in. disk, 2-in. suction, 166 gpm, 80-ft total dynamic head				32.7	685
Pump, centrifugal, tlr-mtd, 500 gpm, 20-ft total dynamic head				151.6	1,980
Pump, centrifugal, gas, base-mtd, 500 gpm, 90-ft total dynamic head				173.4	2,510
Pump, centrifugal, gas tlr-mtd, 1,000 gpm, 80-ft total dynamic head				556	8,335
Pump, sump, 175 gpm at 25-ft head, 2½-in. discharge				3	190
Reproduction set, black and white process				10	230
Reproduction set, gelatin process				3.4	104
Saw, circular, wood, ptbl, 10-in.	13	9	11	.75	11
Semitrailer, low-bed, 20T, front loading	435	115	76	2,145	23,900
Sheet metal handset No. 1				65	2,600
Shop equip, base maint elec rep				224	5,720
Shop equip, mach shop, base maint.				3,590	75,000
Shop equip, GP rep, stir-mtd				1,910	22,700
Shop equip, org rep, lt-trk-mtd	318	94	129	2,230	22,120
Shop equip, set No. 8 welding				320	6,250
Shovel, front, for crane, crawler, 10T				433	6,700
Sign painting set				9	268
Supplementary equip, hv shop co				545	47,100
Supplementary equip, maint co				523	17,650
Surveying set, GP				28	474
Tool kit, blacksmith, gen				29	1,160
Tool kit, diesel injector rep, fld maint				2.6	62
Tool kit, mason and concrete fin- ishers				7.6	103
Tool kit, pipefitters, gen				7	200
Tool kit, pipefitters, supplemental				9	45
Tool kit, precision inst rep				11	308
Tool kit, rigging, wire	34	16	10	3.5	167
Tool kit, sheet metal workers, hand				7	176
Tool set No. 6, engr machinist's	20	8	11	1	20
Torch outfit, cutting and under- water welding	48	36	57	57	1,120
Torch outfit, cutting and welding				50	1,300
Tractor, whl, gas, 3,725 to 5,175-lb DBP	116	58	73	261	3,282
Tractor, crawler, diesel, 12,000- to 17,000-lb DBP, w/bulldozer	190	95	73	764	22,800
Tractor, tracked, diesel, w/angle dozer 17,000- to 24,000-lb DBP	219	98	80	995	35,600
Tractor, tracked, diesel, w/bull- dozer, 24,100- to 32,000-lb DBP	240	104	90	1,300	40,000
Trailer, 4W, tandem, 10T, flatbed	150-330	93	48	1,188	7,200

Item (uncrated unless otherwise noted)	Length (in.)	Width (in.)	Height (in.)	Cu. ft.	Weight (lb.)
ENGINEER—Continued					
Truck, crash, Army acft, w/fire- fighting equip.....	294	96	106	1,740	21,000
Welding shop, trl-mtd, 300 amp.....				420	4,900
Wheelbarrow, 3 cu ft (when heaped).....				6.8	74
MEDICAL:					
Candler, egg, aluminum.....				.167	2.08
Comparator, color, hydrogen, cho- rophenol red.....				.187	6
Dispensary, medical set, field.....				2	70
Egg insp kit, vet.....				1	25
Food insp kit, vet.....				1	20
Food insp kit, vet.....				1.33	50
Litter, folding, aluminum pole.....	49	8.4	6	1.43	23
Medical fld set, supplemental sup.....				2.3	45
Medical kit, indiv, crated.....	15	8	6	.41	8
Stove, gasoline, 2-burner, crated.....	15	6	8	.48	16.3
Tester, milk-sediment, King.....				1.13	12
ORDNANCE:					
Carbine, cal .30.....	35.6				5.6
Carrier, cargo, M29C.....	192	67	71	403	4,800
Carrier, lt wpn, inf, ½T, 4×4, M274.....	118.25	49	27.5	81	900
Demolition equip set No. 2 plat°.....				4.6	85
Dolly, 10T, 2W, M365.....	114	96	54	340	3,400
Grinder, bench, hand-powered 6 × 1¼-in. wheel.....				.36	11.3
Jack, hydraulic, 10T.....				12.7	338
Launcher, rocket, 3.5-in. M20A1.....	60			.8	43
Machine gun, cal .30, BRG, M1919A.....				.8	34
Machine gun, cal .50, AN-M3, Acft, basic.....				1.7	69
Machine gun, cal .50, BRG, M2, hv bbl.....	65				82
Machine gun, 7.62mm, M60 w/ flash suppresser.....	44.5				23
Mount, AA, MG, cal .50, M63.....					144
Mount, pedestal, MG, cal .50, M65.....	82				825
Mount, tripod, MG, cal .50, M3.....					44
Mount, bipod, rifle, M2.....	13.25				1.75
Pistol, auto, cal .45.....	8.6				2.4
Pistol, pyrotechnic.....	8				2.13
Recovery vehicle, medium.....	234	106	108	1,880	61,700
Rifle, U. S., cal .30.....	43.6				9.5
Rifle, M14, 7.62mm.....	35.3				9.1
Semitrailer, cargo, 6T, van, 2W, MSKD 2181.....	248	96	130	1,797	7,170
Semitrailer, van, 7½T, reorg, 2W, lightweight.....	275	96	130	1,980	6,600
Semitrailer, cargo van, 12T, 4W.....	344	97	109	2,102	13,800
Semitrailer, 12½T, 4W.....	600	97	93	3,116	13,000
Semitrailer, low-bed, 25T, 8W.....	404	116	64	1,711	13,000
Semitrailer, tank transporter, 50T, 8W, M15A2.....	462	146	105	3,490	42,600
SigC rep shop, trk-mtd, 2½T, 6×6, M185.....	254	96	117	1,651	15,270
Sled, cargo, 1T, M14A1.....	116	51	50	169	600

See footnotes at end of table.

Item (uncrated unless otherwise noted)	Length (in.)	Width (in.)	Height (in.)	Cu. ft.	Weight (lb.)
ORDNANCE—Continued					
Sled, cargo, 10T-----	288	96	36	575	10,000
Submachine gun, cal .45-----				.47	13
Tool set, armorer's-----				1.1	57
Tool set, auto fuel and elec-----				.67	18
Tool set, electrician's No. 2-----				.5	10
Tool set, gen mechanic's-----				1.24	42.2
Tool set, 2d ech, No. 1 common-----				47.5	959
Tool set, 2d ech, No. 1 supplement-----				1.4	51
Tool set, 2d ech, No. 2 common-----				139.5	2,715
Tool set, 2d ech, No. 2 supplement-----				131	3,076
Tool set, 2d ech, No. 4, block and tackle-----				1.84	89.5
Tool set, machinist's-----				1.2	42
Tool set, metal body rep-----				1.25	39.6
Tool set, welder's-----				1	31
Trailer, fuel, svc, 600-gal-----	151	89	71	622	3,000
Trailer, 2T, 4W, generator-----	199	96	63	694	4,000
Truck, command, ¾T, 4×4, M42-----	185	74	90	695	6,000
Truck, gas tank, 2½T, 6×6, 750-gal-----	254	91	93-82	1,242	10,800
Truck, shop van, 2½T, 6×6, M535-----	256	96	118-94	1,340	10,000
Truck, dump, 2½T, 6×6-----	249	85	104	1,270	13,800
Truck, dump, 2½T, 4×2-----	220	91	92	1,070	8,200
Truck, wrecker, 2½T, 6×6-----	288	91	119	1,805	16,000
Truck, 5T, 4×2, S&P-----	292	96	90	1,266	10,450
Truck, tractor, 8T, 6×4 ^d -----	285	86	104	1,476	14,300
Truck, tractor, 10T, 6×6-----	280	114	113	1,962	28,755
QUARTERMASTER:					
Adding and subtracting mach, elec or hand-operated, 10-col-----				2.16	48
Adding and subtracting mach, hand, 8-col-----				3.1	65
Bag, canvas, water w/ropes and cover-----				.52	11.3
Burner, oil-stove, tent-----				2.29	59.4
Can, gasoline, 5-gal-----				.95	9.5
Can, water, 5-gal-----				1.4	8
Chair, folding, metal-----				.99	11.5
Conveyor, gravity roller, 45° curve, 18 in. wide, 10-ft sec-----	120	18	3	8	165
Desk, field, empty, fiber, co-----				2.7	39
Desk, field, M-1945-----				4.3	68
Fly, tent, wall, large, w/o pins and poles-----	258	173		1.6	50
Heater, immersion-----				6.2	72
Heater, tent, gasoline, 250,000 BTU-----				57.9	596
Lantern, gasoline-----				.28	2.7
Machine, calculating, nonlist, elec, 8-col-----				2.73	75
Machine, computing, list, 10-col cap-----				8.3	50
Machine, duplicating, stencil, hand-operated-----				5.2	80
Organ, folding, chaplain, w/case-----				6.14	109
Outfit, cooking, 1-burner-----				.11	4.6

Item (unrated unless otherwise noted)	Length (in.)	Width (in.)	Height (in.)	Cu. ft.	Weight (lb.)
QUARTERMASTER—Continued					
Outfit, cooking, small detachment				4.33	123
Outfit, off mess				2	45
Parachute, pers, back, 28 ft	42.5	39.5		1.79	31
Paulin, duck, OD, 17×12 ft	204	144		^b 2.3	57
Paulin, duck, OD, 40×20 ft	480	240		^b 6.7	250
Pump, bbl, rotary, kerosene or gas w/6-ft hose and nozzle			58	2.44	50
Pump, gas, ptbl, gas-eng drive, 50 gpm	29	22	44	25.6 (crated)	380
Safe, field, comb. lock				3	150
Stove, cooking, gasoline, 1-burner				8.87	185
Tank, fuel, skid-mtd, 750-gal, 2 compartment	72	72	56	237 (crated)	1,100
Tent, CP, w/pins and poles	165	120	108	^b 9.9	257
Tent, GP, med, w/pins and poles	396	192	120	^b 19	455
Tent, kitchen, w/pins and poles	216	144	108	^b 26	419
Tent, maint, w/frame and pins	322	218	164	^b 84.3	1,255
Tent, wall, small, w/pins and poles	106	110	102	^b 7.5	115
Tent, wall, large, w/pins and poles	174	168	132	^b 8.9	275
Trailer, whse, 4,000-lb, 36×84-in. caster steering	84	36	14	24.5	1,000
Truck, fork, gas, 3,500 lb ^f	120	78	108	585	6,770
Truck, fork, gas, 6,000-lb, rough terrain ^f	195	84	122	1,160	16,600
Truck, fork, gas, 10,000-lb, rough terrain ^f	216	102	131	1,660	26,300
Truck, fork, gas, 15,000-lb, 210-in. lift ^f	192	92	154	1,566	19,330
Truck, hand, 2W, w/folding wing	52	18		5.9	18
Truck, hand, platform, 2,500-lb, 36×72-in.	72	36	30	45	200
Truck, oxyacetylene, 2W				16.7	170
Typewriter, nonptbl				2.5	50
Typewriter, ptbl				1.5	35
SIGNAL:					
Detector set, AN/PRS-3	28	13	9.25	^a 4.75	^a 110
Multimeter, AN/PRM-15	8.75	4.75	5.8	.14	
Power unit, PE 75	36	19	24.5	9.7	325
Radiac set, AN/PDR-27				.8	46
Radio set, AN/ARC-44					^a 36.75
Radio set, AN/GRC-7				28	215
Radio set, AN/GRC-9				12.6	256
Radio set, AN/GRC-19					^a 254
Radio set, AN/GRR-5 (packaged)	27	15	46	11	110
Radio set, AN/PRC-6					7.5
Radio set, AN/PRC-8, -9, -10				4.5	62
Radio set, AN/TRC-34					^a 172
Radio set, AN/URC-4					^a 5.75
Radio set, AN/VRC-7					^a 65
Radio set, AN/VRC-9, -10 (crated)				14	^b 299
Radio set, AN/VRC-18				18	429
Radio set, AN/VRC-19				8.5	113
Radio set, AN/VRC-24					82
Radio set, AN/VRC-29					130

See footnotes at end of table.

Item (uncrated unless otherwise noted)	Length (in.)	Width (in.)	Height (in.)	Cu. ft.	Weight (lb.)
SIGNAL—Continued					
Radio set, AN/VRC-34					85
Radio set, AN/VRC-46					70
Radio set, AB/VRC-47					70
Radio set, AN/VRQ-2 (packaged)				8.4	427
Radio set, AN/VRQ-3				23	502
Radio set, AN/VRR-7					50
Radio teletypewriter set, AN/ GRC-46					1,126
Reel unit, RL-31 (crated)					60
Switchboard, SB-22/PT					28.25
Switchboard, SB-86/P					170
Switchboard, SB-993/GT					2.25
Telephone set, TA-43/PT	10.5	6	4	1.46	
Telephone set, TA-312/PT					8.4
Teletypewriter, AN/PRC-1, in case	25	21	17	4.8	43
Term telegraph-telephone, AN/ TCC-14	15.8	11.5	25.75	2.68	70
Tool equip, TE-33				.07	2.2
Tool equip, TE-41	21	7	8	68	29.4
Vibrator pack, PP-68/U	8	8	10	37	70
TRANSPORTATION:					
Airplanes (See ch 2)					
Barge, deck cargo, steel, 570T, 110-ft	1,320	360	110	30,000	344,000
Boat, diesel, plastic, 26-ft	312	97	72	1,260	6,810
Boat, picket, diesel, steel, 46-ft Des 4003	557	151	158	7,673	22,400
Boat, picket, diesel, wood, 65-ft Des 4002	779	191	192	16,512	69,400
Boat, work, diesel, steel, 65-ft	786	212	252	24,318	132,000
Book, reference library, rail set, No. 7				5.5	98
Book, reference library, rail set, No. 8				3	55
Cargo set, cleaning, in gear box	72	50	61	125	1,610
Cargo set, coopering and shoring, in gear box	72	48	61	123	2,148
Cargo set, drum handling, in gear box	72	48	72	144	3,780
Cargo set, hatch, 5T, in gear box	72	50	61	126	3,140
Cargo set, hv, lift, 50T, in gear box	81	48	72	162	4,250
Cargo set, lighting, in gear box	73	51	61	132	1,780
Cargo set, plate handling, in gear box	36	30	31	19.2	378
Cargo set, riggers', in gear box	72	50	44	92	
Cargo set, timber handling, in gear box	72	36	27	41	1,037
Cargo set, vehicle handling, in gear box	130	31	29	67	880
Cargo transporter (box, metal, shipping, steel, cap. 295 cu ft, max load 9,000 lb)	102	75	83	366	1,500
Crane, floating, diesel elec, steel, 60T	1,704	696	924	98,400	1,800,000
Crane, floating, revolving, diesel elec, steel, 89 LT	1,680	840	1,030	122,500	3,151,680

Item (uncrated unless otherwise noted)	Length (in.)	Width (in.)	Height (in.)	Cu. ft.	Weight (lb.)
TRANSPORTATION—Continued					
Drier, sand, external grating, 7T to 10T		52 (dia)	56	87.6	1,137
Fender, marine, rubber-filled	24	7 (dia)			
Forge, blacksmith, ptbl, w/blower, 40½ × 37 × 3 in.				130	200
Forge, blacksmith, ptbl, 220V, 42 × 38 × 7 in.				130	200
Forge, riveting, ptbl, 10 × 10 × 5 in. w/burner, oil-fired				3.75	216
Former, slip-roll, bench, hand, 2-in., dia rolls, 36-in. cap., 22 gage				33.7	480
Grinder, bench, 2-spindle, 220V, 3 to 4 in. dia	15	12	15	1.6	90
Grinder, bench, tool and cutter, 220V, 12-in. dia work	18	16	25	4.17	64
Helicopters (See ch 2)					
Landing craft, diesel, steel, Mark VIII, LCM (8), 70-ft	884	252	164	21,090	134,400
Landing craft, diesel, steel, 115-ft	1,380	408	261	85,043	403,200
Lathe, eng, hv dy, 20½-in. swing, 48-in. centers, 16-spd				453	13,730
Lighter, amphibious, 5T (LARC-5)	420	120	122	3,570	9,000
Lighter, amphibious, 60T (BARC)	751	319	233	32,542	199,000
Locomotive, diesel-elec, 36-, 39¾-, 42-in., 48T, 0-4-4-0 road switcher	420	102	136	3,380	116,000
Locomotive, diesel-elec, 56½-, 60-, 63-, 66-in., 60T, 0-4-4-0 road switcher	420	102	136	3,380	116,000
Locomotive, diesel-elec, 36½-, 39¾-, 42-in., 80T, 0-6-6-0 road switcher	504	108	131	4,130	144,000
Locomotive, diesel-elec, 56½-, 60-, 63-, 66-in., 120T, 0-6-6-0 road switcher	642	116	163	3,380	232,400
Locomotive, steam, 36-, 39¾-, 42-in., 60T, 2-8-2 tender	429	103	136	3,465	104,000
Propelling unit, diesel, outboard, 165 hp	285	103	136	2,285	41,600
Pump, reciprocating, 12.5 gpm, 2-in. suction, steam, ¾-in. discharge ^k					19,300
Railway car, push, multigage, 6T, 4W				8	300
Railway motor car, multigage, 8-man, 4W					630
Railway car, 36-, 39¾-, 42-in.					2,600
Ambulance, kitchen-diner-storage	735	100	134	5,650	91,000
Ambulance, pers.	735	100	134	5,650	90,000
Ambulance, ward	735	100	134	5,650	92,000
Railway car, 56½-, 60-, 63-, 66-in.					
Flat, depressed center, 80T	492	116	40	1,334	76,000
Gondola, high-side, 40T	531	114	105	3,640	35,400
Shaper, metal work, floor, 20-in., std dy				190	5,100

See footnotes at end of table.

Item (uncrated unless otherwise noted)	Length (in.)	Width (in.)	Height (in.)	Cu. ft.	Weight (lb.)
TRANSPORTATION—Continued					
Shear, sheet metal, 52- X 18-in., 16 gage-----					1,995
Sheet metal mach, cap. 18-gage iron-----				33.7	480
Tool set, boiler and smith shop co-----				432	18,238
Tool set, car repair co-----				169	9,663
Tool set, diesel-elec plat-----				34	3,117
Tool set, erecting and mach shop-----				536	22,105
Tool set, railway maint of way, No. 4-----				334	10,283
Tool set, railway maint of equip, No. 5-----				1,525	41,645
Tug, harbor, diesel, steel, 240 hp, 45-ft, Des 320-----	543	150	^a 180	8,475	56,000
Tug, harbor, diesel, steel, 600 hp, 65-ft-----	852	246	357	30,054	224,000
Tug, harbor, diesel, steel, 1,200 hp, 100 ft-----	1,284	318	^a 444	104,914	^a 660,800

^a Weight will vary slightly with different makes and models.

^b Folded.

^c Less explosives.

^d 10-ton may be issued.

^e Data are for one section.

^f Without forks.

^g Add 30 percent for crating.

^h Less components.

ⁱ Less wire.

^j Without diesel engine.

^k In place on 11-gpm.

^m Towed overseas after special preparation.

ⁿ Minimum height with top hamper removed.

^o Hull only.

^p Capable of moving over seas under own power.

7.5 Packaged Missiles and Other Special Ammunition

Weapon	Container and contents	Container dimensions (in.)			Cube (cu ft)	Gross weight (lb)	Remarks
		Length	Width	Height			
Hawk-----	Complete round-----	216	28	42		3,270	Date applicable only when guidance section is shipped separately.
	Guidance section-----	90	29	34		715	
Nike-Ajax-----	Warhead, M-2-----	15¼	7⅞	10½	35.4	35.4	Wood crate (2 per crate)
	Warhead, M-3-----	28	14	17	3.85	212	Wood crate
	Warhead, M-4-----	26	12	16	2.9	153	Wood crate
	Missile body section, M-2	265½	38½	41	250	2,495	Reusable steel container
	Fin JATO, M-12-----	42¼	40½	12½	12.6	166	Wood crate (3 per crate)
	Fin control and stabilizer-	76¼	22⅞	27	26.5	220	Wood crate (4 M-9 fins and 4 M-10 fins per crate).
	Rocket motor, M-5-----	175¼	24¾	26½	66.5	1,883	Wood crate
	Igniter, rocket motor, M-24-----	25⅞	15⅞	17½	4.3	191	1 igniter per metal can (18 cans in a wood crate).
	Propellant mixture, M-3	20⅝	20⅝	11½	2.8	63.3	Aluminum drum

Weapon	Container and contents	Container dimensions (in.)			Cube (cu ft)	Gross weight (lb)	Remarks
		Length	Width	Height			
	Starting mixture.....	11 $\frac{5}{8}$	10 $\frac{1}{8}$	12 $\frac{1}{8}$	82	18	Wood crate (4 bottles plus 1 filling assembly per crate).
	Nitric acid.....	21 $\frac{3}{4}$	21 $\frac{3}{4}$	28	7.67	380	Reusable aluminum drum
	Explosive, harness assembly M-45.....	24 $\frac{5}{16}$	14 $\frac{15}{16}$	8 $\frac{1}{2}$	1.7	36.5	Wood crate (1 assembly per sealed can—10 cans per crate).
Nike-Hercules.....	Warhead assembly, HE...	100	54	62	193.5	3,170	Reusable metal container
	Missile body section.....	224	55	62	435.5	4,606	Reusable metal container
	Rocket motor, XM-30...	106	44	48	124.8	3,844	Wood crate
	Rocket motor, XM-42E2...	180	43	54	243	6,520	Special reusable wood container.
	Rocket motor, M5E1.....	177	25 $\frac{1}{4}$	54	81.5	1,883	Wood crate
	Rocket motor, XM-42 (fin assembly).....	52	30	52	46.9	600	Wood crate
	Fin assembly.....	148	29	42	104.3	1,050	Wood crate (4 main fins, 4 center fins, and 4 elevons per crate).
	Booster thrust structure...	38 $\frac{3}{8}$	38 $\frac{3}{4}$	46 $\frac{1}{4}$	40.1	395	Wood crate
	Safety and arming device, M30A1.....	16	10	8	.66	25	Wood crate
	Battery, BB401/V.....	20	13	11	1.54	65	Wood crate
	Ethylene oxide.....	15 $\frac{1}{2}$	15 $\frac{1}{2}$	49 $\frac{1}{2}$	6.82	280	Pressurized cylindrical container.
Little John.....	Warhead section, XM50...	100	28 $\frac{88}{100}$	34 $\frac{88}{100}$	50	962	Reusable metal container
	Warhead, practice, 318-mm, XM8.....	100	28 $\frac{88}{100}$	34 $\frac{88}{100}$	50	962	Reusable metal container
	Rocket motor, 318mm, XM26E1.....	126	38	38	105.5	1,392	Reusable metal container
Lacrosse.....	Warhead, HE T34E2.....	96	36	39	78	1,200	Reusable metal container
	Body assembly.....	182	41	45	194.3	3,497	XM4E2 reusable metal container.
	Rocket motor, XM10E1...	117	26	29 $\frac{3}{4}$	52.4	1,232	Reusable wood container
	Computer, missile guidance.....	24 $\frac{1}{2}$	17 $\frac{3}{4}$	13 $\frac{1}{2}$	3.25	70	Wood crate
Sergeant.....	Warhead and forebody...	164	49	51	234	2,430	XM421 reusable aluminum container.
	Rocket motor.....	224	48	51	319	8,000	XM419 reusable aluminum container.
	Guidance section.....	125	49	51	177	2,100	Reusable aluminum container.
	Fin assembly.....	56	12	36	13.7	120	Reusable aluminum container.
Honest John.....	Warhead assembly, 762-mm rocket, M1A2, with flash smoke, XM4E3, XM4E4.....	146	46	53	205	3,410	Wood crate
	Warhead assembly, 762-mm rocket with flash smoke, XM38.....	146	46	53	197	3,099	Wood crate
	Rocket motor, XM50.....	235	38	47	242.8	5,590	Wood crate
	Rocket motor, M3A2.....	240	39	49	264	6,538	Wood crate

Weapon	Container and contents	Container dimensions (in.)			Cube (cu ft)	Gross weight (lb)	Remarks
		Length	Width	Height			
	Fin, 762-mm rocket, M136A1-----	60	17	49	29	345	Wood crate
	Accessories can-----	15	15	16	2.1	46	
Corporal-----	Warhead, XM15-----	34 ¹ / ₁₆	34 ¹ / ₁₆	45 ³ / ₄	32.1	1,614	Wood crate
	Body section, GM, fore, M3-----	69 ⁷ / ₈	38 ³ / ₈	39 ⁹ / ₁₆	63.7	425	Special reusable container
	Body section, GM, aft, M4, M4E5, M4A1-----	461	49	58	758	9,107	M351 metal container
	Missile body, aft, M4, M4A1, XM4E2-----	461	59	58	758	9,107	M351 metal container
	Fin assembly-----	92 ¹ / ₃	46 ¹ / ₄	22 ¹ / ₁₆	54.6	571	Reusable wood container
	Propellant, aniline, fur- fural alcohol-----		26 ⁷ / ₈	35	14.6	515	Special reusable alumi- num drum.
	Propellant, nitric acid, fuming-----		25 ⁵ / ₁₆	29 ¹ / ₂	10.6	521	Special reusable alumi- num drum.
Pershing-----	Warhead section-----	168	52 ¹ / ₂	53	271	2,600	Reusable lightweight steel container.
	Guidance and control sec- tion-----	84	65	72	288	2,488	Reusable lightweight steel container.
	Rocket motor, first-stage section-----	141	65	70	377	3,683	Reusable lightweight steel container (cube data also applies to second stage, weighing 6,933 lbs).
Redstone unit----	Warhead unit-----	252	96	106	1,477	19,770	Van-type semitrailer, 2 wheel.
	Thrust unit-----	520	96	132	3,802	23,000	Van-type semitrailer, 2 wheel.
	Aft unit-----	184	96	106	1,080	8,360	Van-type semitrailer, 2 wheel.
	ST 80 stabilized platform	52	52	49	76.6	895	Reusable 2-piece cylin- drical container.
	Container, hydrogen per- oxide-----	28	28	49	22.2	980	Cube is for each con- tainer; weight is total.
	41 containers, alcohol----	23	23	40	12.3	15,990	
	Accessories box-----	72	72	72	216	5,000	
SS-10 and SS-11--	SS-10 complete round----	30	28	29	14.1	189	Wood crate
	SS-11, complete round----	40	20	24 ¹ / ₂	6	157	Wood crate
Redeye-----	(Shipping data is classified)						
Mauler-----	Complete round-----	80	10	10	4.6	140	In canister; 4 canisters palletized for shipment.
Shilleglash-----	(Shipping data is classified)						
Nike-Zeus-----	(Complete round is 55 feet long, 7 ¹ / ₂ feet in diameter, and weighs approx- imately 20,000 lbs)-----						Still in developmental stage.

Weapon	Container and contents	Container dimensions (in.)			Cube (cu ft)	Gross weight (lb)	Remarks
		Length	Width	Height			
Davy Crockett...	Complete round.....	37¾	16	16	5.6		Wood box (weight is classified).
8-in. Howitzer.....	Shell.....	50	12	12	4.2	163	
	Charge, propellant.....	30	10	10	1.7	53	
	Accessories parts can.....	12	12	15	1.25	33	
	Spare accessories.....	12	12	15	1.25	30	
	Restructor.....	34	10½	11½	2.37	57	
	Carrying case, M102.....	25	16	16	3.7	135	
	Carrying case, M102.....	25	16	16	3.7	230	
280-mm gun.....	Shell.....	75	21	24	21.8	770	
	Charge, propellant.....	84	13	13	8.2	221	
	Spare accessories can.....	32	9	9	1.5	56	
	Carrying can, M102.....	25	16	16	3.7	230	
	Carrying can, M102.....	25	16	16	3.7	135	
	Carrying can, M103.....	25	16	16	3.7	160	
UFD/ADM*.....	FDAC.....	37	24	24	12.3	100	
	Munition warhead.....	60	40	40	55.5	1,500	
	Accessories can.....	24	24	32	10.66	100	
TADM*.....	Munition warhead.....	69	25	34	33.8	825	
	Misc container.....	24	24	27	8.98	150	
Project A ADM*.....	Munition warhead.....	93	37	45	89.5	1,540	
	DFD, T46E2.....	53	30	30	27.6	500	
	Power supply, MK 2.....	25	23	23	7.65	118	
	Accessories can.....	12	12	15	1.25	22	
	Testers.....	25	25	23	8.32	50	
	Spares can.....	12	12	19	1.58	37	
	Carrying case, M102.....	25	16	16	3.7	130	
	Wire.....	50	24	26	18.0	520	
T4 ADM*.....	Tube assembly.....	26	9	9	1.22	41	
	Base assembly.....	11	11	11	.77	60	
	Tools.....	20	12	10	1.39	35	
	Squab cans.....	7	7	5	.14	10	
	Igniter container.....	5	4	2	.023	1	
	Carrying case, M102.....	25	16	16	3.7	135	
	Carrying case, M102.....	25	16	16	3.7	230	
	Fuze.....	12	11	10	.76	20	

* ADM refers to atomic demolition munitions.

7.6 Materials Handling Equipment

The items of materials handling equipment listed below are those normally used by terminal service personnel. For the most part these items are authorized by TOE or TA. The straddle

trucks listed in *f* below are not normally transportation TOE or TA items, but may be obtained by special authorization when needed. For more complete information, see TM 10-1619.

a. Forklift Trucks. (Gasoline power, pneumatic tires.)

Capacity (lb)	Lift height (in.)	Free lift (in.)	Fork length (in.)	Load center (in. from heel)	Weight (lb)	Dimensions (in.)		
						Height	Length	Width
3,500	144			24	6,770	108	120	78
4,000	144	22	40	24	7,660	95	104	45
6,000	168	6¾	40	24	10,375	115	113	68
10,000	210	2	48	24	14,145	150	136	77
15,000	210	2½	48	24	18,330	150	152	96

b. Rough-Terrain Forklifts.

Capacity (lb)	Lift (in.)	Fork length (in.)	Gradeability (percent)	Turning radius (ft)	Lift tilt (degrees)		
					Forward	Back	Left-right
6,000	144	48	45	15	45	30	10
10,000	144	60	45	17	45	30	10

c. Warehouse Tractors. (Gasoline power, pneumatic tires.)

Drawbar pull (lb)	Towing capacity (ton)	Loaded speed (mph)	Weight (lb)	Dimensions (in.)		
				Height	Length	Width
4,000	90	12	5,220	57	111	66
7,500	200	9.47	12,386	72	130	96

d. Warehouse Cranes. (Gasoline power, pneumatic tires.)

Capacity (lb)	Sluing range	Loaded speed (mph)	Weight (lb)	Dimensions (in.)		
				Height	Length	Width
10,000	180°	15	20,800	95	295	94
10,000	180°	12	20,000	260	273	96

e. Warehouse Trailers.

Capacity (lb)	Tires	Construction	Length (in.)	Width (in.)
4,000	Steel or rubber.....	Wood.....	72	36
4,000	Steel or rubber.....	Wood.....	84	36
4,000	Steel or rubber.....	Wood.....	84	48
6,000	Pneumatic.....	Wood.....	108	48
20,000	Solid rubber.....	Steel.....	144	72

f. Straddle Trucks. (Gasoline power, pneumatic tires, four-wheel steering.)

Capacity (lb)	Loaded speed (mph)	Weight (lb)	Dimensions (in.)		
			Height	Length	Width
30,000	35	12,500	114	187	92
30,000	35	13,250	123	187	92
30,000	35	13,000	124	188	105
30,000	35	14,800	159	192	96

g. Crawler and Truck-Mounted Cranes. The table below gives ratings and clearances and can be used to determine lifting capacity for different boom lengths and positions. The actual lifting capacity of any particular crane, for a given boom length and position, can be found on the vehicle name plate or in the vehicle technical manual. The letters used in the table indicates the following:

R = Radius (horizontal distance between end of boom and center of rotating table) in feet

A = Angle in degrees that boom makes with the horizontal

C = Lifting capacity in pounds

D = Distance in feet and inches between top of boom and ground

R	A	C	D	A	C	D	A	C	D
	45-foot boom			50-foot boom			55-foot boom		
12	80	52,100	49' 9"	80	52,100	54' 10"			
15	76	37,100	49' 2"	77	36,800	54' 3"	78	36,600	59' 5"
20	69	24,500	47' 7"	71	24,300	52' 11"	73	24,100	58' 2"
25	62	18,100	45' 4"	65	17,800	50' 11"	68	17,600	56' 4"
30	55	14,200	42' 3"	59	14,000	48' 3"	61	13,800	54' 0"
35	46	11,600	38' 2"	51	11,300	44' 9"	56	11,100	40' 11"
40	36	9,700	32' 6"	43	9,400	40' 3"	49	9,200	47' 1"
45	24	8,200	24' 1"	34	7,900	34' 2"	42	7,800	42' 2"
50				23	6,800	25' 1"	33	6,700	35' 8"
55							22	5,800	26' 1"
	60-foot boom			65-foot boom			70-foot boom		
20	75	23,900	63' 4"	76	23,700	68' 6"			
25	69	17,400	61' 9"	71	17,200	67' 0"	73	17,000	72' 3"
30	64	13,600	59' 7"	66	13,400	65' 1"	68	13,200	70' 6"
35	59	10,900	56' 11"	62	10,700	62' 8"	64	10,600	68' 3"
40	53	9,000	53' 6"	56	8,800	59' 8"	59	8,700	65' 7"
45	47	7,600	49' 4"	51	7,400	55' 11"	54	7,300	62' 3"
50	40	6,500	44' 1"	45	6,300	51' 5"	49	6,100	58' 3"
55	32	5,600	37' 2"	38	5,400	45' 10"	43	5,200	53' 6"
60	21	4,900	27' 1"	30	4,600	38' 6"	36	4,500	47' 6"
65				20	4,100	28' 0"	29	3,900	38' 10"
70							19	3,400	28' 10"

7.7 Weapons and Accessories

Item	Weight		Length (in.)	Feed	Cooling	Max. range		Max. effec.		Muzzle velocity (fps)	Rate of fire (rds/min)	Traverse (mils)	Magazine capacity	Firing mechanism	Weight of projectile			Operation	Sights		Groove diameter of bore (in.)	Elevation (mils)	Depression (mils)	Shipping data									Remarks
	lb	oz				yd	meters	yd	meters						lb	oz	gr.		Front	Rear				No. per box	Length (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Gross wt (lb)	MT	Stowage factor		
Bayonet, knife, M4, w/scabbard, M8, for carbine, M1.		9	11.75																					50	19.75	15	16	2.74	63	0.07	96	Bayonet M4	
																								100	29.6	16.76	14.5	4.16	112	0.11	83	Bayonet M4	
																								100	26.5	17.75	16	4.4	70	0.11	141	Scabbard M8	
																								200	49.5	17.75	16	8.2	145	0.21	127	Scabbard M8	
Bayonet, knife, M1, w/scabbard, M1, for rifle M1.		14	14.44																					100	28.5	22.2	17.25	6.3	175	0.16	81	Bayonet M1	
																								100	32.6	16.0	12.25	3.7	135	0.09	61	Scabbard M7	
Carbine, cal .30, M1.	5	5	35.5	Magazine	Air	2,200	2,010	276	250	1,970	Semi-automatic		15	Trigger		108	Gas	Blade (fixed)	Aperture (adj)	0.3070				10	41.75	18.5	11.75	5.3	113	0.13	105		
Gun, machine, cal .30, BRG, M1919A6.	32 ^a	8 ^a	53	Link belt	Air	3,500	3,200	900	820	2,800	600-650			Trigger			Recoil	Blade (adj)	Aperture and open (adj)	0.3080				1	43.75	7	9	1.0	59	0.04	61		
Gun, machine 7.62mm, lightweight, general purpose.	23	2.6	43.5	Link belt	Air	3,500	3,200	900	820	2,800	550			Trigger		147	Gas	Blade (fixed)	Aperture and open (adj)	0.3080				1	47.5	7.5	9.5	2.0	50	0.05	90		
Gun, machine, cal .50, M2, BRG, hv hbl, flex.	82		65	Link belt	Air	7,460	6,820	2,000	1,830	2,930	450-555			Press sear release side plate Trigger		710	Recoil	Blade (semi-fixed)	Leaf (adj)	0.5105				1	69.5	9	10.25	3.7	128	0.09	65		
Gun, machine, cal .50, BRG, M2, hv hbl.	82		65	Link belt	Air	7,460	6,820	2,000	1,830	2,930	450-555			Trigger		710	Recoil	Blade (semi-fixed)	Leaf (adj)	0.5105				1	69.5	7.75	10.12	3.2	117	0.09	61		
Gun, machine, cal .50, AN-M3, acft, basic.	64 ^b	8 ^b	67.25	Link belt	Air	7,275	6,640	2,000	1,830	2,840	1,150-1,250			Solenoid		710	Recoil	None*	None	0.5105				1	61.6	8.25	10.12	3.0	97	0.08	69		
Gun, submachine, cal .45, M1928A1.	8		33.38	Magazine	Air	1,760	1,610	100	90	920	600-725		20 or 30	Trigger		234	Gas	Blade	Leaf	0.4500				10	29	14.75	10.75	2.7	140	0.067	43		
Launcher, grenade, M7A3, for rifle M1.		14	9	Single loading	Air	330 175	300 ^d 160 ^e	125	115	180	As loaded			Blank in rifle	1 ^f	8 ^f	Manual	None*	None*	0.875 ^h				50	21.5	18.5	10	2.3	62	0.06	83		
Launcher, rocket, 3.5 inch, M20A1B1.	14		60.25	Single loading	Air	960	875	300	275	340	As loaded			Electric	9		Manual	Rocket sight M39	3.50				4	36.5	33.25	16	11.3	150	0.28	169			
Mount, AA, machine gun, cal .50, M63.	144											6,400									1,495	516	1	36.25	23.5	17.5	8.6	233	0.22	83			
Mount, tripod,	19	8										6,400 ⁱ									150 ^j	200 ^j	2	34	9	15	2.7	70	0.067	87			

- h With bipod and shoulder stock.
- i Weight does not include recoil adapter assembly, which weighs 4 ¼ pounds.
- j Tracers used for fire direction.
- k Rifle grenade.
- l Hand grenade.
- m Average (varies with different types of grenades).
- n M15 sight mounted on rifle.
- o Outside diameter of tube.
- p Traversing range without releasing mechanism is 100 mils.
- q Figures shown are controlled elevation and depression. Free elevation is 445 miles; free depression is 445 mils.
- r Traversing range without releasing elevating mechanism is 800 mils.
- s Weight shown includes mount, which weighs 1 lb, 4 oz.
- t Length shown includes mount, which is 1.69 inches long.
- u Height of burst.
- v Varies between 1 and 1 ½ lb.
- w Firing weight is 10 lb, 2 oz.
- x With flash suppressor.
- y Firing weight is 11 lb.

7.8 Telephone Poles

Class		1	2	3	4	5	6	7
Minimum top circumference (in.)-----		27	25	23	21	19	17	15
Transverse breaking loads (lb)-----		4,500	3,700	3,000	2,400	1,900	1,500	1,200
Type	Length (ft)	Average weight (lb)						
Western cedar-----	20	700	600	500	400	300	225	200
Northern cedar-----	20	720	600	540	350	300	230	190
Creosoted pine-----	20	635	555	479	418	353	310	259
Western cedar-----	25	850	720	600	480	400	320	250
Northern cedar-----	25	1,020	780	600	515	420	300	250
Creosoted pine-----	25	898	808	686	602	508	423	362
Western cedar-----	30	1,000	850	730	610	500	420	350
Northern cedar-----	30	1,320	1,170	870	630	520	420	350
Creosoted pine-----	30	1,241	1,076	921	780	672	573	489
Western cedar-----	35	1,200	1,000	850	750	650	560	470
Northern cedar-----	35	1,620	1,380	1,060	820	720	510	450
Creosoted pine-----	35	1,603	1,410	1,213	996	865	733	616

Western and northern cedars are furnished butt-treated; pine is treated full length. To estimate required shipping space, use the following formula.

$$\frac{\text{Average weight (lb)} \times \text{constant}}{40} = \text{measurement tons}$$

Values of the constants are: Cedar—0.052
Pine—0.026

Section III. COLD WEATHER DATA

7.9 Sled Train

a. Power Vehicle Specifications.

Type	Gross weight (lb)	Cubic feet	Dimensions (in.)			Per-sonnel	Fuel cap. (gal.)	Speed (mph)					Drawbar pull (lb)		Payload towed	Fuel consumption (avg)	Turn-ing radius (ft)	Engine
			Length	Width	Height			Gear					Direct drive	Torque con-ver-ter				
								1	2	3	4	5						
M29C Weasel...	5,971	403	193	67.3	71	4	35	4	7	10	12	20	NA	None	3,800 lb	5 mpg	12	Studebaker Champion
M76 Otter.....	12,162	1,180	193	98	103.3	10	60	8 avg	18 avg	28 max	----	----	Cross drive	None	6,000 lb	2.3 mpg	12	Continental Model, A01, 268-38
M116 Husky.....	10,000	-----	182	80.5	79.5	12	65	-----	-----	-----	-----	-----	-----	-----	-----	4.6 mpg	-----	Chevrolet
D7 LPG.....	47,515	1,870	232	132	123.75	1	65	2	3	5	7	10	15,000	None	30 to 40 tons	135 gal. per day	24	Caterpillar D337
D8 LPG M54...	58,780	3,360	288	160	126	2	100	2	3	5	7	10	20,000	27,500	30 to 40 tons	135 gal. per day	24	Caterpillar D337
D8 LPG M55...	83,000	3,360	288	160	126	2	918	1.5	1.9	2.8	3.8	5.2	32,000	None	30 to 40 tons	135 gal. per day	24	Caterpillar D342

b. Sled Specifications.¹

Characteristics	1-ton recon sled		2 1/2-ton farm sled	10-ton ATACO steel skis	10-ton ATACO Micarta skis	Fuel transporter
	1952	1953				
Gross weight (lb)-----	1,225	1,390	1,375	7,000	7,000	10,271
Cubic feet-----	75	128	282	1,367	1,460	403.92
Dimensions:						
Length-----	10' 9"	13' 10 1/2"	15' 8"	22' 4" w/o tongue	22' 4"	24'
Width-----	5'	7' 1 1/2"	7' 2"	8' 6"	8' 6"	10'
Height-----	1' 5"	1' 4 3/4"	2' 6"	7' 3" to top of stakes	7' 8" to top of stakes	4' 6"
Capacity-----	2,000 lb	2,000 lb	2 1/2 tons	10 tons	10 tons	3,021 gal.

¹ A plastic boat-type sled is also available and used extensively in northern areas. It weighs 38 pounds, is 88 inches long, 25 inches wide, and 8 inches deep, and has a 200-pound capacity.

c. *Wanigan Specifications.* A wanigan is a small house, normally constructed of plywood, lumber, and insulating material; usually mounted on runners; and transported in tractor-drawn sled trains. Interior designs vary; it may be used as a kitchen, shop, bunk-house, etc.

Characteristics	Command, M54	Passenger, M52	Passenger, M54	Command, M55	Crew, M53	Crew mess, M54	Crew, M55	Mess, M55
Weight, empty (lb)-----	10,500 (est)	10,500 (est)	11,400 (est)	15,000	16,000 (est)	18,000	19,000	19,000
Cubic feet-----	1,560	1,560	1,870	2,600	3,310	2,868	3,790	3,790
Dimensions:								
Length-----	20'	20'	24'	26'	35'	45'	38'	38'
Width-----	10'	10'	10'	12'	8' 7"	8' 6"	12'	12'
Height-----	7' 2"	7' 2"	8' 6"	10' 3"	7' 8"	7' 6"	10' 3"	10' 3"
Number of persons accommodated-----	4	10	12	6	18	16	24	18
Fuel used-----	Diesel oil	Diesel oil	Diesel oil	Diesel oil	Diesel oil	Coal	Diesel oil	Diesel oil

d. Other Data.

(1) Fuel consumption per day.

(a) Coal stove for heating.

- 20 pounds of coal or 12 Presto logs for summer operations (10° F. or above).
- 50 pounds of coal or 30 Presto logs for winter operations (10° F. or below).

(b) Coal stove for cooking.

- 50 pounds of coal, or
- 30 Presto logs.

(c) Generator fuel consumption.

- 5-kw generators burn approximately 20 gallons of gasoline in continuous operation.
- 30-kw generators burn 30 gallons of diesel fuel oil (VVF 800).
- 45-kw generators consume 35 gallons of diesel fuel oil (VVF 800).

(d) Yukon stove for heating.

Burns 5 gallons of gasoline in a 10-12 hour period while heating the 10-man Artic tent in temperatures of 0° F. and lower.

This stove will also burn wood or coal.

(e) Starting motors or pumps.

Based on an average of 1-hour operation per day are rated at 0.2 of a gallon of gasoline.

(2) Lubrication consumption.

(a) Engine oil consumption for large, general-purpose tractors is rated at 2 gallons per day. The rate is considered equal for OE 30-10-5. The consumption rate for a light vehicle is .006 gallon per mile.

(b) The rate of gear oil consumption is .45 gallon per mile for a large, general-purpose tractor; .006 gallon per mile for a light vehicle.

(c) GAA is used as an all-purpose grease (also used for water pumps, etc.). Consumption rate is .005 of a pound per mile.

(d) Consumption rates for generators, starting motors, and pumps are based

on operations listed in (1)(c) and (e) above.

- (3) **Antifreeze.** Each vehicle will have its initial antifreeze put in before embarking on a cold-weather operation (par. 7.11).

7.10 Load-Bearing Capacity of Ice

The strength of ice varies with the structure of the ice, the purity of the water from which it is formed, the cycle of formation (freezing, thawing, and refreezing), temperature, snow cover, water currents, and whether or not the ice is water supported. Although the sustaining capacity of ice cannot be determined accurately, experience and tests provide the working capacity figures given below for good quality fresh-water ice.

Load	Ice thickness in CM ¹		Distance in meters between units ²
	Risk	Normal	
Single soldier on skis.....	4	5	5
File of soldiers—2-pace interval.....	8	10	
Vehicles:			
Truck, ¼T.....	15	20	15
Truck, ¾T.....	20	25	20
Truck, 2½T.....	35	40	25
Truck, 5T.....	45	55	60
Tractor and trailer loaded, ST.....	80	90	80
M116.....	30	35	15
M113.....	40	45	25
D7 tractor.....	45	50	40
D8 tractor.....	50	60	50
Crane, 20T.....	55	60	70
Grader.....	35	40	50
Tank M41.....	50	65	60
SP M52.....	55	65	50
APC M59.....	45	55	50
Tractor M8A2.....	55	65	70
Aircraft:			
UH-1A.....	20	25	--
OH-13.....	15	18	--
CH-21.....	30	35	--
CH-37.....	45	50	--
O-1A.....	15	20	--
U-6A.....	20	25	--
U-8D.....	20	25	--
U-1A.....	25	30	--

¹ Multiply by .3937 to obtain inches.

² Multiply by 3.2808 to obtain feet.

7.11 Guide for Preparation of Antifreeze Solutions

Lowest expected ambient tempera- ture (° F.)	Arctic grade antifreeze (-90° F.) (MIL-C-11755)	Ethylene-glycol antifreeze (-60° F.) (spec. O-E-771a, type I)		De- naturaed alcohol (grade III) ¹ Pints per gallon of coolant capacity ²
		Pints per gallon of coolant capacity ²	Specific gravity (68° F.)	
+20	Freezing point of -90° F.	1½	1.022	1½
+10	-----	2	1.036	2¼
0	Issued ready for use and must not be mixed with any other liquid.	2¾	1.047	2¾
-10	-----	3¼	1.055	3¼
-20	-----	3½	1.062	3½
-30	-----	4	1.067	4½
-40	-----	4¼	1.073	5
-50	-----	4½	-----	-----
-60	-----	4¾	-----	-----

¹ Used as temporary emergency expedient when neither arctic grade antifreeze nor ethylene-glycol antifreeze is available.

² Includes heaters, etc.

7.12 Temperature, Snow cover, and Precipitation in Arctic and Subarctic Areas

Figures below may be used as guides for preliminary planning of operations in the areas shown, keeping in mind that seasonal storms may cause some of the figures to vary for short periods of time. For windchill factors, see figure 7.1. The planner should obtain further information concerning the particular area and should allow appropriate safety factors when planning for individual clothing, winterization of equipment, etc. Temperatures in the table are not averages, but are the high and low extremes for each month for each place shown. The figures showing snow cover indicate expected snow depths and should not be confused with precipitation of snow, since packing and partial melting reduce residual quantities. Mean annual precipitation includes snowfall and rain, with the total represented as inches of water (1 inch of water equals 10 inches of snow). Generally speaking, most of the precipitation above 70° latitude is snow, while that below 70° latitude is rain. This rule should be used with discretion; however, since other factors (longitude, sea currents, air currents, etc.) affect the type and quantity of precipitation.

Location	North Latitude		January		February		March		April		May		June		July		August		Septem-ber		October		Novem-ber		Decem-ber		Snow cover (in.)		Mean annual precipitation (in.)			
	Deg	Min	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Maximum depth and month	Average yearly depth for periods shown	Snow	Rain	Total	
Alaska:																																
Anchorage.....	61	10	-40	+49	-45	+49	-25	+54	0	+64	+20	+84	+35	+84	+40	+84	+30	+84	+20	+74	0	+64	-20	+54	-35	+44	27.8 (Jan)	6.39 (Oct-Mar)	-----	-----	14.3	
Aniak.....	61	35	-65	+49	-60	+49	-45	+54	-30	+59	-5	+74	+30	+84	+30	+94	+20	+84	+10	+69	-20	+64	-40	+54	-55	+44	32.3 (Jan)	6.85 (Oct-Apr)	-----	-----	19.0	
Barrow.....	71	18	-55	+29	-55	+24	-45	+29	-35	+34	-15	+39	+15	+64	+25	+74	+20	+74	+5	+64	-15	+44	-40	+39	-50	+29	22.5 (Mar)	10.70 (Sep-May)	-----	-----	5.3	
Barter Island.....	70	7	-50	+34	-60	+24	-40	+34	-40	+34	-15	+44	+20	+64	+25	+74	+25	+64	+5	+64	-20	+44	-55	+39	-50	+34	-----	-----	-----	-----	5.0	
Big Delta.....	64	0	-60	+49	-60	+49	-40	+54	-20	+69	+15	+89	+20	+89	+35	+94	+20	+84	+5	+74	-20	+59	-45	+54	-60	+39	54.3 (Jan)	11.20 (Sep-May)	-----	-----	15.0	
Cordova.....	60	30	-25	+49	-35	+49	-15	+59	+5	+64	+20	+79	+30	+79	+35	+84	+30	+79	+20	+69	+15	+74	-15	+54	-20	+49	29.0 (Jan)	8.05 (Oct-Apr)	132	131.8	145.0	
Fairbanks.....	64	49	-60	+39	-60	+44	-40	+54	-20	+69	+15	+89	+30	+94	+35	+94	+20	+84	+10	+74	-15	+64	-40	+49	-60	+34	54.3 (Jan)	9.67 (Sep-May)	-----	-----	11.9	
Galena.....	64	43	-60	+39	-60	+39	-45	+54	-30	+64	-5	+84	+30	+89	+40	+89	+30	+84	+15	+69	-15	+59	-50	+44	-60	+39	-----	12.87 (Oct-Apr)	-----	-----	17.0	
Kotzebue.....	66	52	-45	+34	-50	+39	-40	+34	-25	+44	-20	+74	+20	+84	+30	+84	+30	+79	+15	+74	-10	+54	-35	+39	-45	+34	48.3 (Mar)	13.19 (Sep-May)	-----	-----	9.0	
Nome.....	64	30	-45	+39	-50	+54	-40	+44	-25	+54	-15	+69	+25	+79	+30	+74	+25	+74	+15	+64	-5	+59	-40	+44	-45	+39	74.0 (Mar)	15.70 (Oct-May)	-----	-----	17.4	
Umiat.....	69	22	-60	+34	-60	+29	-55	+39	-50	+59	-25	+59	+20	+74	+30	+89	+20	+79	-5	+64	-30	+49	-55	+44	-60	+34	22.5 (Mar)	10.70 (Sep-May)	-----	-----	5.0	
Wales.....	65	37	-35	+34	-40	+44	-35	+39	-25	+44	-5	+59	+20	+64	+35	+69	+30	+74	+25	+54	+10	+49	-15	+44	-30	+34	74.0 (Mar)	15.69 (Oct-May)	-----	-----	10.5	
Wiseman.....	67	26	-60	+39	-60	+34	-40	+39	-30	+49	-5	+79	+30	+84	+35	+89	+25	+79	+5	+59	-25	+44	-45	+34	-55	+29	-----	-----	-----	-----	7.5	
Canada:																																
Aklavik.....	68	14	-50	+29	-60	+44	-40	+44	-35	+59	-15	+74	+20	+84	+35	+84	+30	+79	+15	+69	-15	+59	-40	+39	-55	+39	48.0 (Mar)	14.10 (Oct-Apr)	40.0	5.0	9.0	
Alert.....	82	30	-55	+9	-50	+14	-50	+9	-40	+29	-15	+44	+15	+59	+25	+69	+5	+54	-15	+44	-30	+19	-40	+24	-50	+9	-----	-----	10.0	Neg	1.0	
Arctic Bay.....	73	0	-45	+24	-55	+34	-50	+24	-40	+29	-10	+39	+15	+59	+30	+64	+30	+59	+10	+49	-15	+34	-40	+34	-40	+14	13.0 (Mar)	8.55 (Sep-Apr)	40.0	3.0	7.0	
Baker Lake.....	64	18	-50	-1	-50	+14	-30	+19	-35	+34	-15	+39	+15	+59	+30	+74	+30	+69	+15	+49	-10	+39	-30	+29	-40	+19	17.5 (Apr)	10.34 (Nov-Apr)	50.0	6.0	11.0	
Cambridge Bay..	69	7	-55	+19	-55	+14	-45	+19	-40	+24	-15	+44	+15	+64	+30	+69	+25	+64	+10	+54	-20	+39	-40	+24	-50	+19	17.0 (Apr)	9.31 (Sep-May)	36.0	4.0	7.6	
Chesterfield.....	63	20	-50	+34	-55	+29	-50	+29	-40	+39	-20	+44	+10	+74	+30	+84	+30	+74	+15	+59	-10	+49	-35	+39	-50	+24	32.0 (Dec)	13.54 (Oct-May)	53.0	6.0	11.3	
Clyde.....	70	27	-40	+14	-45	+24	-45	+24	-30	+19	-10	+39	+20	+44	+25	+59	+25	+59	+20	+44	-5	+34	-20	+34	-40	+19	25.0 (Apr)	14.82 (Feb-Apr)	65.0	4.0	10.5	
Coppermine.....	67	49	-55	+14	-55	+29	-45	+29	-35	+39	-15	+64	+15	+84	+30	+84	+30	+79	+15	+69	-25	+59	-40	+34	-40	+24	69.0 (Apr)	18.82 (Oct-May)	40.0	5.0	9.0	
Coral Harbor.....	64	12	-55	+9	-55	+29	-35	+24	-35	+29	-15	+39	+20	+54	+30	+79	+25	+69	+10	+49	-10	+34	-35	+34	-50	+29	40.0 (Feb)	17.81 (Oct-May)	59.0	5.0	10.9	
Dawson.....	64	4	-60	+39	-60	+49	-35	+49	-40	+64	+10	+84	+25	+89	+35	+94	+25	+84	+15	+74	-5	+64	-50	+49	-60	+44	45.0 (Feb)	15.13 (Oct-Apr)	45.0	7.5	12.0	
Eureka.....	80	0	-60	+24	-60	-1	-60	+9	-50	+29	-20	+44	+10	+59	+30	+69	+15	+59	-15	+39	-45	+29	-50	+29	-60	+14	-----	15.37 (Oct-May)	10.0	Neg	1.0	
Fort Providence..	61	20	-60	+29	-55	+24	-40	+54	-25	+64	+10	+74	+25	+89	+35	+89	+25	+94	+5	+79	+10	+74	-40	+49	-60	+49	33.0 (Dec)	12.83 (Oct-Apr)	45.0	8.0	12.5	
Fort Smith.....	61	1	-50	+44	-60	+54	-40	+49	+10	+84	-35	+79	+25	+89	+35	+99	+25	+94	+15	+84	-5	+74	-35	+44	-55	+44	33.0 (Mar)	10.90 (Oct-Apr)	42.0	8.5	12.7	
Frobisher Bay....	63	45	-53	+44	-50	+39	-45	+39	-30	+39	-15	+54	+15	+69	+30	+79	+20	+74	+15	+59	-5	+44	-35	+29	-35	+34	74.0 (Mar)	21.10 (Oct-Apr)	80.0	7.5	15.5	
Holman Island...	70	30	-45	+9	-45	+19	-35	+19	-25	+39	-5	+39	+20	+69	+30	+74	+25	+64	+10	+44	0	+34	-25	+19	-30	+9	16.0 (Mar)	5.73 (Oct-May)	34.0	3.5	6.9	
Isachsen.....	78	47	-60	+19	-60	-6	-60	+9	-40	+29	-15	+34	+10	+54	+25	+64	+10	+59	-10	+34	-30	+29	-45	+19	-55	+14	-----	-----	10.0	Neg	1.0	
Mould Bay.....	76	14	-60	+9	-55	-1	-55	+14	-40	+29	-15	+34	+10	+59	+25	+59	+15	+59	-15	+39	-25	+29	-45	+24	-60	+14	-----	-----	15.0	1.0	2.5	
Norman Wells....	65	17	-50	+24	-60	+24	-30	+49	-15	+59	+10	+74	+30	+89	+35	+89	+30	+89	+5	+69	-5	+49	-35	+24	-55	+14	51.4 (Jan)	17.34 (Oct-Apr)	40.0	7.0	11.0	
Nueltin Lake.....	60	30	-50	+19	-55	+19	-40	+39	-35	+49	-10	+69	+25	+74	+40	+84	+35	+79	+15	+69	-20	+54	-30	+39	-40	+24	-----	-----	55.0	9.0	14.5	
Padloping Island..	67	6	-50	+29	-50	+24	-45	+29	-25	+44	-15	+49	+15	+59	+25	+74	+25	+64	+5	+64	+5	+59	-35	+44	-40	+34	65.0 (Jan)	49.00 (Jan-Apr)	-----	-----	15.0	
Resolute.....	74	43	-55	+24	-55	+9	-55	+19	-35	+29	-15	+39	+10	+59	+30	+64	+15	+59	0	+44	-25	+34	-40	+29	-55	+19	25.6 (May)	12.44 (Oct-May)	30.0	1.0	4.0	
Snag.....	62	22	-60	+34	-60	+44	-40	+54	-50	+59	0	+89	+25	+89	+30	+84	+25	+79	-5	+74	-20	+59	-55	+34	-60	+34	-----	-----	60.0	8.0	14.0	
Watson Lake.....	60	7	-60	+44	-60	+44	-40	+49	-20	+59	+20	+84	+25	+84	+35	+89	+20	+84	+20	+79	-20	+69	-40	+49	-60	+39	37.8 (Feb)	15.55 (Oct-Apr)	60.0	9.5	15.5	
Whitehorse.....	60	43	-60	+44	-60	+49	-25	+49	-15	+59	+20	+84	+25	+84	+30	+84	+20	+84	+15	+79	+5	+59	-45	+49	-55	+49	21.8 (Feb)	6.73 (Oct-Apr)	50.0	9.5	14.5	
Yellowknife.....	62	28	-60	+39	-60	+34	-40	+39	-25	+64	0	+69	+30	+84	+40	+89	+35	+89	+20	+69	0	+64	-30	+39	-50	+39	32.0 (Jan)	12.79 (Oct-Apr)	40.0	7.5	11.5	

[illegible]

THE WINDCHILL FACTOR

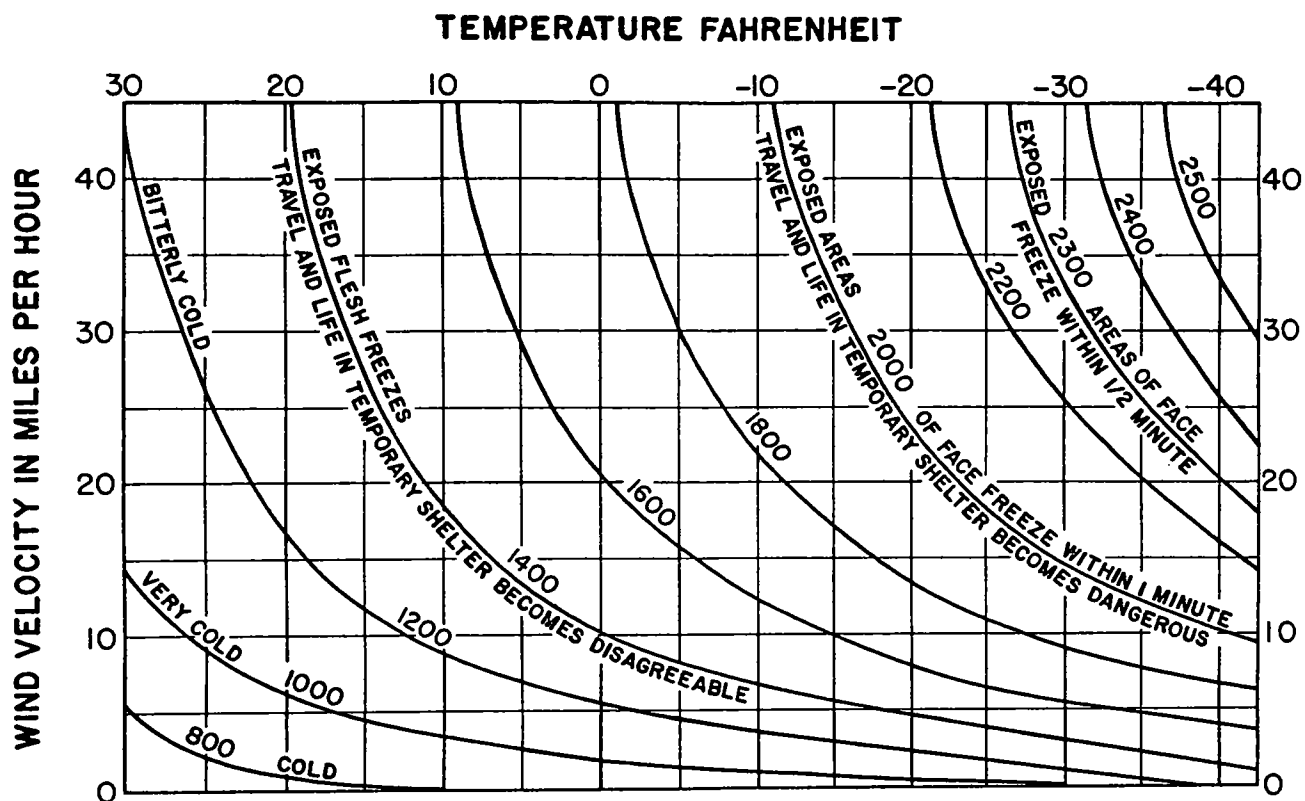


Figure 7.1. The windchill factor.

7.13 Storage Batteries

a. The electrolyte in acid-type storage batteries is normally composed of sulphuric acid and pure water. The proportion of these two substances determines the specific gravity of the electrolyte, and the specific gravity, in turn, determines the state of charge of the battery. When the battery discharges, water is formed, causing a reduction in specific gravity. When the battery charges, sulphuric acid is formed, causing an increase in specific gravity. When the ratio of acid to water is such that the specific gravity is 1.275 to 1.300 at 80° F., the battery is fully charged. The proportions of acid to water shown below are used to make electrolytes of various specific gravities at 80° F. Freezing points of the resulting electrolytes are also shown.

Parts concentrated sulphuric acid to one part of water		Specific gravity	Approximate freezing point °F.
By volume	By weight		
0.232	0.416	1.200	-16
0.250	0.454	1.210	-25
0.294	0.527	1.240	-51
0.364	0.667	1.280	-90

b. Extreme cold of arctic and subarctic areas has an adverse effect on storage batteries. At -30° F. the available energy from a battery is only about 10 percent of what it would be at 80° F. For efficient operation, battery temperatures should be kept from dropping below +30° F. This is normally accomplished through the use of winterization kits. Also, the specific gravity must be kept in the 1.275 to 1.300 range, when corrected to a temperature of +80° F. Specific gravity changes about 0.002 for each 5° temperature change below or above 80°. Specific gravities and

approximate state of charge for various temperatures are given below.

Temperature °F.	Specific gravity (cor- rected for temperature)	Approximate state of charge (percent)
+80	1.000 (water)	Fully discharged
+80	1.130	Discharged
-75	1.213-1.238	46
-70	1.215-1.240	48
-65	1.217-1.242	50
-60	1.219-1.244	52
-55	1.221-1.246	54
-50	1.223-1.248	56
-45	1.225-1.250	58
-40	1.227-1.252	60
-35	1.229-1.254	62

Temperature °F.	Specific gravity (cor- rected for temperature)	Approximate state of charge (percent)
-30	1.231-1.256	63
-25	1.233-1.258	64
-20	1.235-1.260	65
-15	1.237-1.262	68
-5	1.239-1.264	70
-5	1.241-1.266	73
0	1.243-1.268	75
+5	1.245-1.270	77
+10	1.247-1.272	79
+15	1.249-1.274	80
+20	1.251-1.276	82
+25	1.253-1.278	84
+30	1.255-1.280	85
+80	1.275-1.300	100

Section IV. CARGO CONTAINERS, PALLETS, AND MARKINGS

7.14 Reusable Metal Shipping Box and Containers Inserts (fig. 7.2)

Figure 7.2 illustrates two reusable metal shipping boxes (cargo transporters). To facilitate handling and loading small articles, insert containers may be used with the cargo transporter. The insert container is a cardboard box with a maximum capacity of 1,000 pounds when strapped to a wooden pallet. Six insert containers fit into the standard cargo transporter (type 2) and four in the half-size (type 1). Container inserts may be used to consolidate small TOE items, thus eliminating multiple handling and much protective packaging. If units are to be moved by air, the inserts may be used as the shipping containers; cargo transporters are not necessary.

7.15 General-Purpose Pallet (fig. 7.3)

The general-purpose pallet is a four-way-entry, wooden pallet, 48 inches long, 40 inches wide, and about 5¼ inches high. It is used primarily for shipping palletized cargo. It may be loaded and shipped from shipper to consignee without the cargo being rehandled. The four-way-entry feature permits easy entrance of the forks of forklift trucks.

7.16 Sled Pallet (fig. 7.4)

The sled pallet consists of a heavy, timbered platform (4 by 6 feet) and runners (4 by 6 inches by 6 feet), upon which 3,000 pounds of supplies and equipment may be secured with steel bands.

The pallet alone weighs 200 pounds. Cables attached to the runners permit towing. Sled pallets may be moved through any surf or over any beach which may be crossed by LVTP's wheeled landing vehicles, or similar craft. Rations, water, fuel in 5-gallon containers, and ammunition are the most suitable supplies for pallet loading.

7.17 Shipment Marking

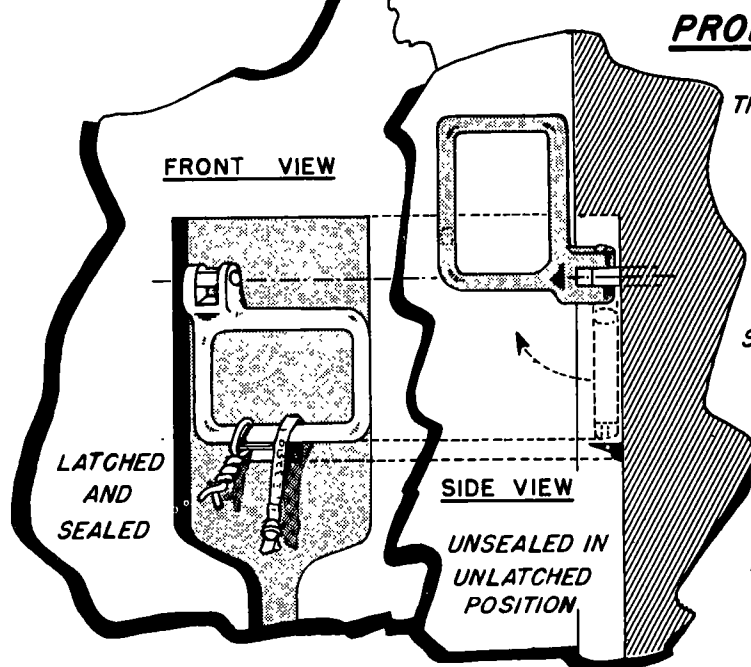
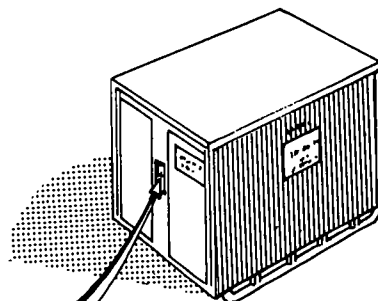
a. General. Address markings identify the consignee, the destination of the shipment, and other pertinent information required for shipment identification purposes. For detailed marking procedures, shipping symbols, and area designators, see MIL-STD-129C, AR 725-50, and Joint Military Standard Transportation and Movement Procedures (MILSTAMP). Terms are defined as follows:

- (1) *In-the-clear address.* A narrative description of the shipping address code.
- (2) *Shipping address code.* A combination of six letters and numbers which depict the in-the-clear address.
- (3) *Required delivery date (RDD).* A numeric calendar date indicating when material is required by the consignee.
- (4) *Port designator.* Three numbers identifying a specific surface terminal or geographic area or location for discharge of cargo.
- (5) *Project code.* Three letters and numbers identifying a specific contingency plan, movement, etc.
- (6) *Air movement designator (AMD).* A

U. S. ARMY - U. S. AIR FORCE**BOX, METAL, SHIPPING, REUSABLE (CARGO TRANSPORTER)****LOADING CHARACTERISTICS**

		TYPE-1 (HALF SIZE)1/	TYPE-2 (STANDARD)
<u>INSIDE</u>	LENGTH	3'-10 5/8"	8'-1 5/8"
	WIDTH	5'-11 3/4"	5'-11 3/4"
	HEIGHT	6'-0 3/8"	6'-0 3/8"
<u>OUTSIDE</u>	LENGTH	4'-3"	8'-6"
	WIDTH	6'-3"	6'-3"
	HEIGHT	6'-10 1/2"	6'-10 1/2"
CARGO CAPACITY		9000 LB	9000 LB
MAXIMUM TARE WT		900 LB	1500 LB
BALE CAPACITY		135 CU FT	295 CU FT
GROSS CUBE		184 CU FT	365 CU FT
GROSS M/T		4.6	9.1

1/ FOR CARGOES WITH OVERALL DENSITY IN EXCESS
OF 45 POUNDS PER CUBIC FOOT

**PROPER SECURITY**

THE APPLICATION OF NUMBERED SEALS
ALONE DOES NOT PROVIDE ANY SECUR-
ITY AGAINST PILFERAGE.

RUPTURED SEALS ARE MERELY AN IN-
DICATION OF A BREACH OF SECURITY.

STOUT WIRE "0" TO "3" GAGE, TIGHTLY
TWISTED & SNUBBED OFF CLOSELY,
WILL PREVENT MOVEMENT OF THE
HANDLE AND DETER THE WOULD-BE
PILFERER.

LOCKS, WIRE CLOSURES, AND SEALS
WILL NOT PREVENT DETERMINED,
ORGANIZED THIEVERY.

Figure 7.2. Characteristics and security of cargo transporters.

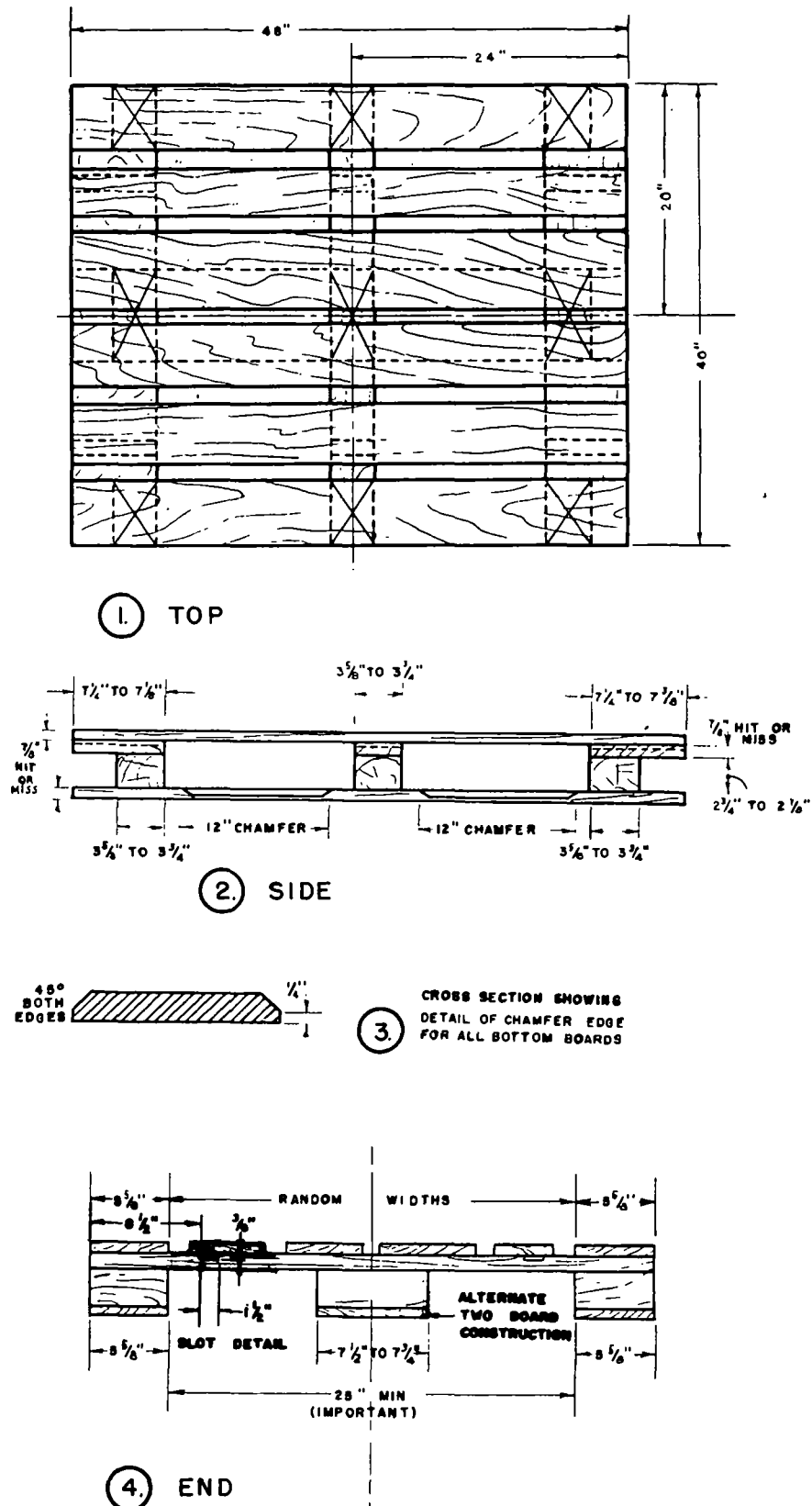


Figure 7.3. Dimensions of general-purpose pallet.

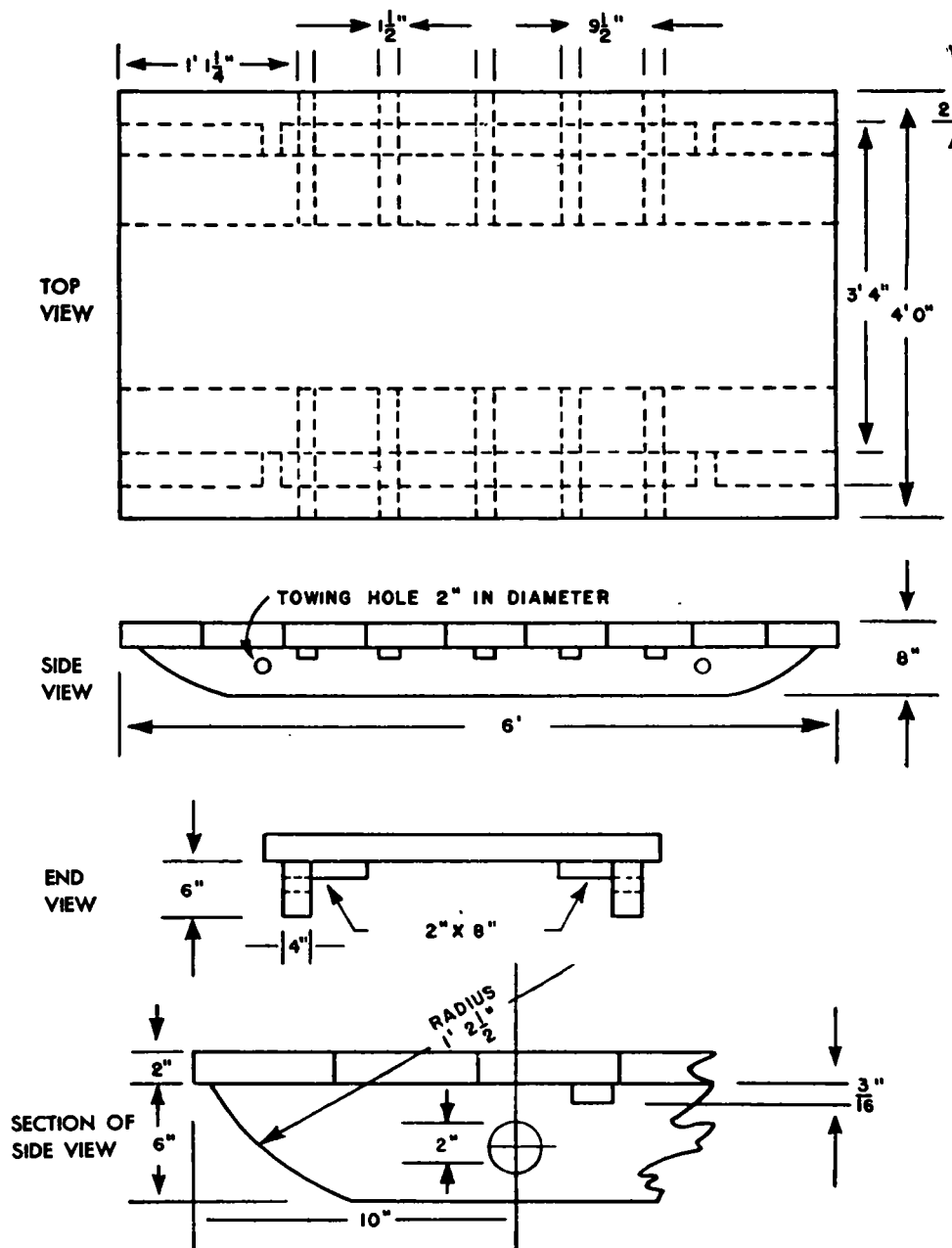


Figure 7.4. Sled-pallet dimensions.

group of letters and numbers assigned to control the movement of shipments by military aircraft.

b. *CONUS Address Marking.* Address marking and AMD, when applicable, are shown on labels or stenciled directly on the container as outlined in the regulations above.

(1) *Example.*

FROM: ROSSFORD ORD DEP
TOLEDO 1 OHIO
TO: TRANS OFF
RARITAN ARSENAL
METUCHEN N J
234
A15034-2182 0001K/75
XYZ

(2) *Explanation.*

FROM: ROSSFORD ORD DEP,
TOLEDO 1 OHIO: Consignor

Line 1. TO: TRANS OFF, RARITAN
ARSENAL, METUCHEN N.J.:
In-the-clear address

Line 2. 234: Required delivery date

Line 3. A15043-2182 0001K/75: Docu-
ment number and total con-
tainers

A15043: Shipping address

A—Service designator

1—Continental Army area

5—State within Army area

04—Depot, DSU, or loca-
tion within State

3—Requisitioner or recipi-
ent within depot, DSU,
or location

2182: Date of requisition

0001: Requisition serial number

K: Suffix to requisition serial
number (when applicable)

75: Total number of exterior
containers

Line 4. XYZ: Project code (when applic-
able)

For shipments via air, the air movement
designator is added as line 5.

Line 5. FFO-WRI-2H-2345-RA-7

FFO—Aerial origin terminal

WRI—Aerial discharge terminal

2—Transportation priority

H—Commodity

2345—Control serial number

RA—Sponsoring agency

7—Month shipped

c. Oversea Address Marking. The oversea
address is the most conspicuous marking on the
container and is as large as available space and
stencil limitations permit.

(1) *Example.*

BRANCONNE GEN DEP FR

AK6500 234 354

AK6500—1207—0120K/98

HAA

(2) *Explanation.*

Line 1. BRANCONNE GEN DEP FR:
In-the-clear address

Line 2. AK6500 234 354: Shipping ad-
dress, required delivery date,
port designator

AK6500: Shipping address

A—Service designator

K6—Area and sub-area

500—Depot or DSU

234: Required delivery date

354: Port designator

Line 3. AK6500—1207—0120K/98:

Document number and total
containers

AK6500: Shipping address (see
above)

1207: Date of requisition

0120: Requisition serial number

K: Suffix to requisition serial
number (when applicable)

98: Total number of exterior
containers

Line 4. HAA: Project code (when ap-
plicable)

d. Domestic Address. Domestic address for
oversea shipments is marked as outlined in MIL-
STD-129C. Composition of domestic address is
as follows:

(1) FROM: (Name of consignor and address)
(City and State)

(2) TO: (Terminal and Address)
(City and State)

(3) Air movement designator when applic-
able

7.18 Service-Color Marking

Service-color markings on export shipment con-
tainers facilitate identification of shipments or
service and assist in the dispersion of supplies to
the proper oversea depots. Generally, these mark-
ings consist of an equal-size triangle in the pre-
scribed service color painted on each adjacent face
of two diagonally opposite corners of the top of the
containers. The altitude of the triangle may vary
from 3 to 8 inches and should be in proportion to
the size of the container. See MIL-STD-129C.
The assigned service colors are shown below; the
number in parentheses is the Federal color speci-
fication number.

a. Army Technical Services.

(1) Chemical Corps—dark blue (35044).

(2) Corps of Engineers—red (11136).

(3) Medical Service—maroon (10049).

(4) Quartermaster Corps—willow green
(14187).

(5) Ordnance Corps—yellow (13538).

(6) Signal Corps—orange (12246).

(7) Transportation Corps—light gray (16376).

b. *Navy*. Black (37038) except as noted below:

- (1) Naval electronics—green (14187).
- (2) Naval medical supplies—maroon (10049).

c. *Marine Corps*.

- (1) Ordnance—yellow (13538).
- (2) Aviation—blue (15193).
- (3) Engineer—red (11136).

(4) Chemical—dark blue (35044).

(5) Electronics—orange (12246).

(6) Medical—maroon (10049).

(7) Quartermaster—willow green (14187).

(8) Post Exchange—willow green (14187) with 3-inch X marked above.

(9) Motor transport—willow green (14187) with 3-inch MT marked above.

d. *National Security Agency*. Purple (27144).

e. *U.S. Coast Guard*. Bright blue (15123).

Section V. COMMUNICATIONS

7.19 Joint Nomenclature System

a. *Classification*. Signal equipment submitted to a joint Army-Navy board is classified by indicator letters as follows:

AN = System indicator for communication-electronic equipment as described in TM 11-487C. AN does not mean that the set is used by both services.

First letter following slash = type of installation.

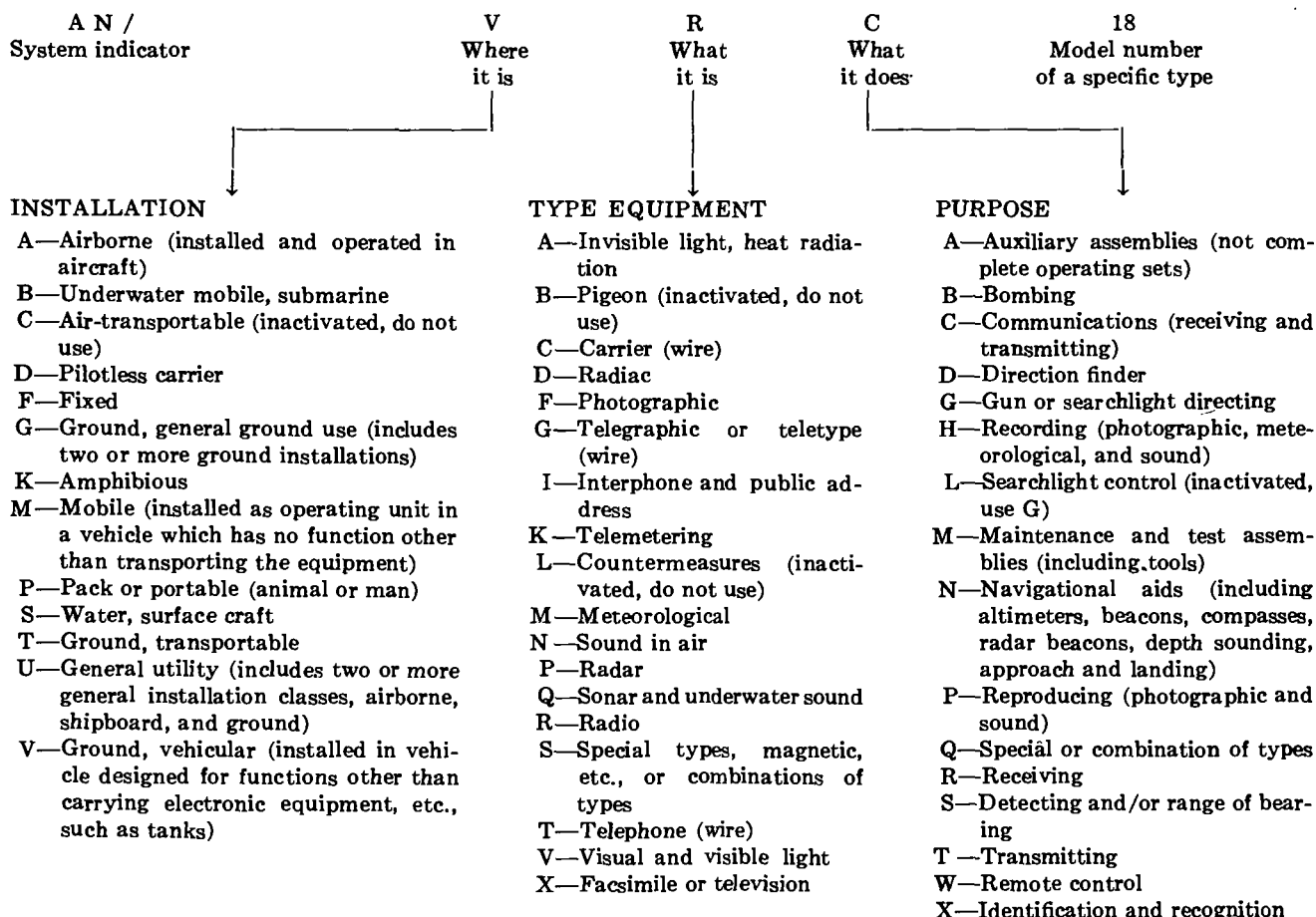
Second letter following slash = type of equipment.

Third letter following slash = purpose of equipment.

Number following dash = particular set.

b. *Example*. AN/VRC-18 = Complete set or major component, ground vehicular installed, radio communication set model 18.

c. *Interpretation*.



7.20 Signals and the Phonetic System

(fig. 7.5)

a. Signals.

- (1) *Morse code.* The Morse code is a language made up of long and short sounds or visual indications representing letters and numbers and used to transmit time and position signals necessary to aviation and navigation and radio and wire messages (FM 21-60). For general telegraphic procedures, see FM 24-18 and ACP 131. The uses of Morse code in aviation are explained in TM 11-2557 and in navigation in Knight's *Modern Seamanship*.
- (2) *Wig-wag.* This is a system for sending international Morse code using a single flag or an improvised sending device (FM 21-60).
- (3) *Semaphore.* This is a system for sending messages using the international alphabet and special prearranged signs. Two red

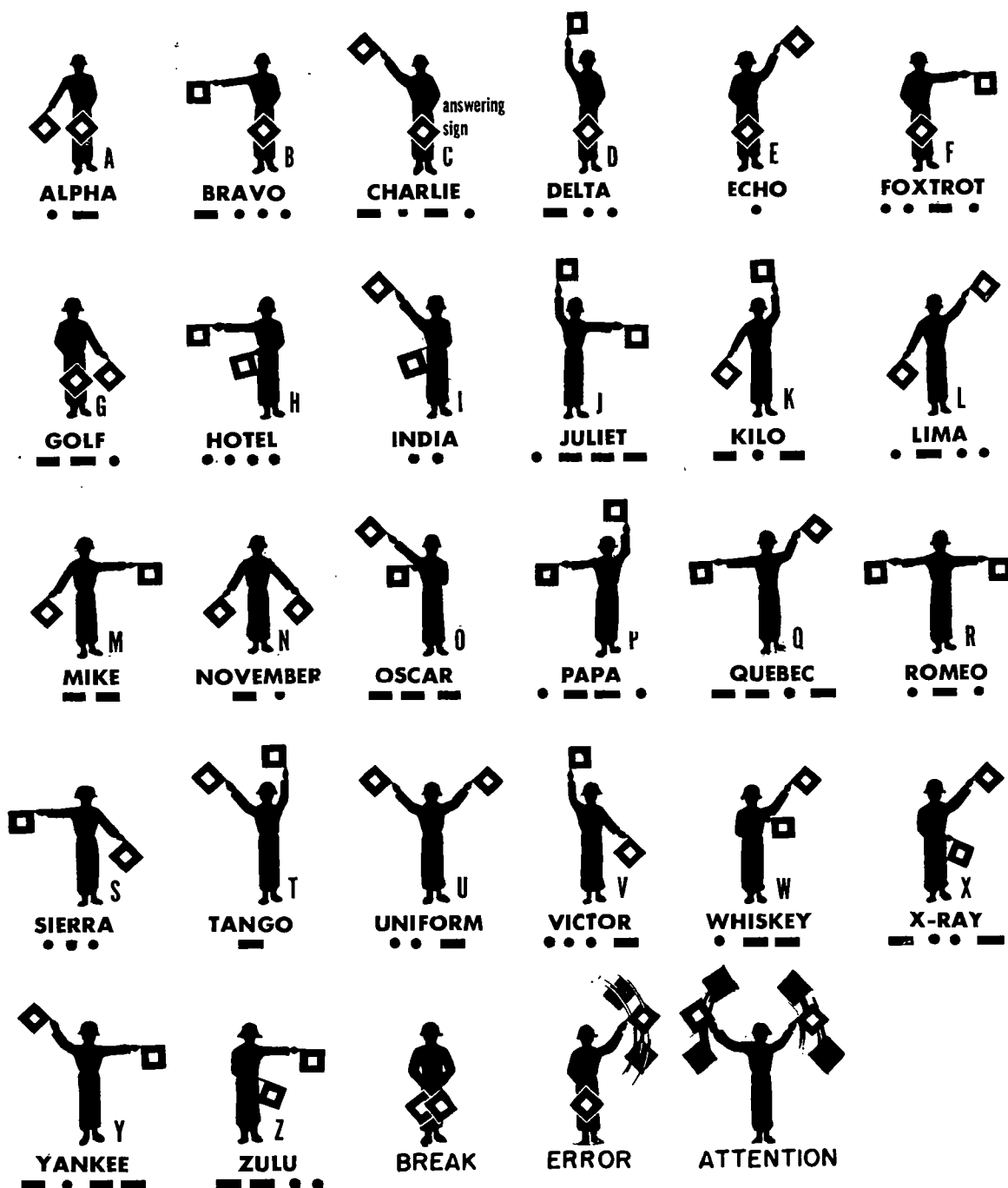
and white flags, 18 inches square, are used. Numerals in the message should be spelled out. All messages end with the ending sign AR. Detailed instructions may be found in Hydrographic Office Publication No. 87 or in FM 21-60.

b. *Phonetic System.* This is a list of standard words used to identify letters and numerals in messages transmitted by radio or telephone. It is used to phonetically spell difficult words or to pronounce code groups, single letters, and numbers that could be misunderstood. For more detail, see FM 24-18.

7.21 Ground-to-Air Emergency Messages

Emergency messages may be sent from the ground to aircraft by arranging panels, torn clothing, parachutes, ditches, rocks, logs, brush fires, and other materials and formations in the shapes shown in figure 7.6. Signals may also be inscribed on snow, soil, or sand. The arrangement must be large enough to be seen from the air (at least 6 ft by 2 ft) and of both color and texture in contrast to its background (FM 21-60).

ALPHABET: SEMAPHORE, PHONETIC, AND MORSE



NUMERALS: MORSE AND PHONETIC

1 • — — — —	4 • • • • —	6 — • • • •	9 — — — — •
	(FO-WER)		(NI-NE)
2 • • — — —	5 • • • • •	7 — — • • •	0 — — — — —
	(FI-FIV)		(ZEE-RO)
3 • • • — —		8 — — — • •	
(THUH-REE)			

Figure 7.5. Semaphore, phonetic alphabet, and Morse code.

① GROUND SIGNALS

1. Require doctor		10. Will attempt takeoff	▷
2. Require medical supplies		11. Aircraft seriously damaged	└─┘
3. Unable to proceed	X	12. Probably safe to land here	△
4. Require food and water	F	13. Require fuel and oil	L
5. Require firearms and ammunition	∨	14. All well	LL
6. Require map and compass	□	15. No	N
7. Require signal lamp with battery and radio		16. Yes	Y
8. Indicate direction to proceed	K	17. Not understood	└┘
9. Am proceeding this direction	↑	18. Require engineer	W

② ACKNOWLEDGMENT BY AIRCRAFT

Message received and understood	{	1. Rocking from side to side 2. Green flashes from signal lamp
Message not understood	{	1. Aircraft will make complete right-hand circuit 2. Red flashes from signal lamp

Figure 7.6. Ground-to-air emergency code.

7.22 Radio Sets

Radio set	Range								Modulation	Frequency range (mc)		Type signal				Vehicle volt required ^d	Weight (lb)
	Voice				CW ^a					Transmitter	Receiver	Voice	MCW ^b	CW ^a	RATT ^c		
	Stationary		Moving		Stationary		Moving										
	KM	Mi	KM	Mi	KM	Mi	KM	Mi									
AN/ARC-44-----	°48	°30	°48	°30	----	No	----	No	FM	24.0-51.9	24.0-51.9	Yes	No	No	No	24	36
AN/ARC-51-----	°48	°30	°48	°30	----	No	----	No	AM	225.0-399.9	225.0-399.9	Yes	No	No	No	24	
AN/ARC-54-----	°48	°30	°48	°30	----	No	----	No	FM	30.0-70.0	30.0-70.0	Yes	No	No	No	24	
AN/ARC-55-----	°48	°30	°48	°30	----	No	----	No	AM	225.0-399.9	225.0-399.0	Yes	No	No	No	24	
AN/GRR-5-----		No		No	----	No	----	No	AM	No	1.5-18.0	No	No	No	No	6, 12, 24	110
AN/GRC-7-----	24	15	16	10	----	No	----	No	FM	38.0-54.9	38.0-54.9	Yes	No	No	No	12, 24	541
AN/GRC-7, Set 2----	1.6	1		No	----	No	----	No	FM	47.0-58.4	47.0-58.4	Yes	No	No	No	12, 24	215
AN/GRC-8-----	24	15	16	10	----	No	----	No	FM	38.0-54.9	38.0-54.9	Yes	No	No	No	12, 24	190
AN/GRC-9-----	40	25	24	15	121	75	56	35	AM	2.0-12.0	2.0-12.0	Yes	Yes	Yes	No	12,24	256
AN/GRC-19-----	80	50		No	121	75		No	AM	1.5-20.0	0.5-32.0	Yes	No	Yes	Yes	24	254
AN/GRC-46-----	80	50		No	121	75		No	AM	1.5-20.0	0.5-32.0	Yes	No	Yes	Yes	24	1,126
AN/PRC-9-----	°5-8	°3-5	^b 13-31	^b 8-19	----	No	----	No	FM	27.0-38.9	27.0-38.9	Yes	No	No	No	24	°62
AN/PRC-10-----	°5-8	°3-5	^b 13-31	^b 8-19	----	No	----	No	FM	38.0-54.9	38.0-54.9	Yes	No	No	No	24	°62
AN/PRC-25-----	5-8	3-5	5-8	3-5	----	No	----	No	FM	30.0-76.0	30.0-76.0	Yes	No	No	No	15 volt bat- tery	15
AN/SRC-8-----	80	50-200	80	50-200	----	No	----	No	AM	2.0-3.5	2.0-3.5	Yes	No	No	No	12, 24, 115	98
AN/TRC-34-----	40	25		No	24	15		No	FM	152.0-174.0	152.0-174.0	Yes	No	No	No	(a.c.)	172
AN/VRC-7-----	1.6	1		No		No		No	FM	47.0-58.4	47.0-58.4	Yes	No	No	No	12, 24	65
AN/VRC-9-----	24	15	16	10	----	No	----	No	FM	27.0-38.9	27.0-38.9	Yes	No	No	No	12, 24	299
AN/VRC-10-----	24	15	16	10	----	No	----	No	FM	38.0-54.9	38.0-54.9	Yes	No	No	No	12, 24	115
AN/VRC 12 Series----	40	25	40	25	----	No	----	No	FM	30.0-75.95	30.0-75.95	Yes				24	90
AN/VRC-19-----	40	25		No	24	15	16	10	FM	152.0-174.0	152.0-174.0	Yes	No	Yes	No	12	113
AN/VRC-19X-----	40	25		No	24	15	16	10	FM	152.0-174.0	152.0-174.0	Yes	No	Yes	No	6	240
AN/VRC-29-----	80	50		No	121	75		No	AM	1.5-20.0	0.5-32.0	Yes	No	Yes	Yes	24	
AN/VRQ-2-----	24	15	16	10	----	No	----	No	FM	27.0-38.9	27.0-38.9	Yes	^k	No	No	12, 24	427
AN/VRQ-3-----	24	15	16	10	----	No	----	No	FM	38.0-54.9	38.0-54.9	Yes	^k	No	No	12, 24	502

^a Continuous wave (radiotelegraph).^b Modulated continuous wave (tone).^c Radioteletypewriter.^d Tactical vehiclea 24 volt only.^e Altitude 1,000 feet.^f Including shelter.^g Short antenna.^h Long antenna.ⁱ With battery.^j Ground mounted.^k 1,600-cycle ringing.

Section VI. FIRST AID AND CBR AND NUCLEAR WEAPONS DEFENSIVE AND PROTECTIVE MEASURES

7.23 First Aid

a. *General.* First aid is the care given to casualties before treatment can be administered by medical personnel. Wounds are the most common conditions needing first aid. The four lifesaver steps in first aid for the wounded are—

- (1) *Stop the bleeding.* Mild bleeding usually stops naturally when a blood clot forms in the wound. For severe bleeding, apply direct pressure to the wound by hand through cleanest available dressing (bandage, cloth, or part of clothing). Elevate injured member if there is no fracture. If bleeding does not slow down then, apply a tourniquet between the wound and the heart. Leave the tourniquet exposed so that it can be seen readily. If possible, mark a "T" on the casualty's forehead (blood may be used) and indicate the time when the tourniquet was applied. The tourniquet should not be loosened or removed at any time except by competent medical personnel.
- (2) *Clear the airway.* Maintain an open airway by tilting the casualty's head as far back as possible so that his neck is stretched with the chin in a "jutting-out" position. Do not allow the chin to sag. Clear his mouth of any foreign matter or mucus. If he is having trouble breathing, start artificial respiration immediately (g below).
- (3) *Protect the wound.* Do not touch the wound with your hands or with anything except the dressing. Do not try to clean the wound.
- (4) *Prevent or treat shock.* A person in shock may tremble and appear to be nervous; he may be thirsty; he may become very pale, wet with sweat, and may pass out. *Treat the wounded man for shock before it appears.* Put him on his back with his head low and feet elevated. Loosen clothing. Keep him comfortably warm with a blanket, coat, poncho, etc. If he is conscious, can swallow, and has no

belly injury, give him hot coffee, milk, or water.

b. *Burns.* A minor burn (small area of reddened skin) should be protected by a sterile dressing if available; otherwise, the burn should be left uncovered. A serious burn (blistering or charring or involving large areas of the body) should be covered with a sterile dressing *only*. Carefully remove or cut away clothing. Do not clean the burn; do not break blisters; do not use any medication whatsoever. Treat for shock. If casualty is conscious, is not vomiting, and has no belly wound, instead of giving warm stimulants, give him small amounts of cool water with salt or salt and soda.

c. *Fractures.* Indications of a broken bone are pain and tenderness near fracture, partial or complete loss of motion; deformity, swelling, discoloration (blueness around point of injury). Handle anyone having a fracture or suspected fracture with gentleness; rough or careless handling causes pain, shock, and damage to blood vessels and nerves. Move the patient only if necessary. Do not attempt to straighten the limb. Support the limb on each side of the fracture until a splint is applied. Splints should be padded and must be long enough to reach beyond joints above and below the break. Do *not* move anyone with a broken leg before it has been splinted. One expedient method of splinting a broken leg is to place a folded poncho, blanket, or jacket between the legs and tie the legs together above and below the break so that the uninjured leg serves as a splint for the injured one. Treat for shock. If there is a wound with the fracture, apply a dressing as you would for any other wound.

d. *Effects of Heat.*

- (1) *Heat exhaustion.* Symptoms are dizziness and faintness; signs are paleness and moist, cool skin. Lay the casualty down in shade, loosen clothing, and give cool salt water if he is conscious.
- (2) *Heatstroke.* In hot surroundings a stoppage of sweating with hot, dry, skin should serve as a warning. The casualty is bright pink and may be delirious. Lower body temperature rapidly by immersing him in cold water. If water is not available, place him in shade, re-

move clothing, and pour water over him. Fan him. Get medical aid. Heatstroke is serious.

e. Frostbite. This is localized freezing of body surfaces with stinging pain at onset, numbness, grayish or white skin. Remove clothes at part affected. Thaw quickly against the body or immerse in warm water (body temperature). After it has thawed, wrap it *loosely* in dry, sterile dressing. Do *not* apply medications. Do *not* open blisters. Get medical aid.

f. Snake Bites. Immediately immobilize the bitten limb in a position below the level of the heart. Apply a tourniquet between the bite and the heart, about 2 to 4 inches above the bite. Tighten the tourniquet just enough to make the veins stand out prominently. If swelling occurs, release the tourniquet and reapply it further up the limb ahead of the swelling. If the patient stops breathing, start artificial respiration at once. Get medical aid immediately.

g. Drowning. The victim may appear to be dead but still be alive. Every moment of delay cuts down his chance of survival. Begin treatment at once. The most important thing is to get air into the victim's lungs immediately. Quickly sweep your fingers through his mouth to clear out foreign matter and mucus; draw his tongue forward. Position him properly to maintain an open airway. His head should be tilted back and his chin should not sag. Begin artificial respiration (the mouth-to-mouth method is preferable) and continue until the victim is breathing naturally or is pronounced dead. Don't wait for a mechanical resuscitator, but if one is available without delay, use it. As soon as victim can breathe for himself, loosen his clothing and treat for shock.

h. Electric Shock. Shock may be caused by contact with electric wires or lightning. The victim may appear to be dead but still be alive. If he has come in contact with an electric current, turn off the switch if it is nearby but do not waste time looking for it. Do not touch person in contact with wire or the wire itself with your bare hands. Use a dry wooden pole, dry clothing, dry rope, or some other material that will not conduct electricity to

remove person from wire. Start artificial respiration immediately, following procedure outlined in *g* above.

i. Carbon-Monoxide Poisoning. Carbon monoxide is an odorless, invisible gas. Poisoning usually results from breathing vehicle exhaust fumes or stove fumes which accumulate in poorly ventilated shelters. It causes dizziness, weakness, headache, vomiting—and then unconsciousness. Get the victim to fresh air and start artificial respiration immediately (*g* above).

j. Care of Feet. Prevention of foot trouble is the best first aid for feet. Keep them clean; bathe them frequently and dry thoroughly between the toes. Use issue foot powder twice daily. If possible, put on clean socks every day. Don't wear socks with holes or poorly darned spots, or those that fit improperly. Make sure shoes fit properly; then break them in before wearing them on a march. Keep toenails clean and short and cut straight across. Don't cut a corn or callus for serious infection may result. If a blister develops and medical aid is not available, wash the spot with soap and water, sterilize a needle with a flame, open blister by sticking it at lower edge, and cover with a sterile dressing. If condition does not improve, see a medical officer.

k. Plant Poisoning. Poison ivy is a creeper with three prominently veined, shiny, pointed leaves on each stem. Poison oak is a woody vine or low shrub with three egg-shaped leaflets and greenish-white flowers in clusters. Poison sumac is a shrub which grows in swamps and has feather-like, shiney green leaves and greenish flowers followed by greenish-white berries. Upon exposure, wash affected parts of body promptly and thoroughly with water and strong soap. Rash starts with redness and intense itching, followed later by small blisters. If rash has already started, do not wash affected area. Scratching makes the condition worse. Get medical attention.

l. Unconsciousness. It is often impossible to find out the cause of unconsciousness, but it may have been caused by bleeding, heatstroke, or head injury. When the cause is known, give the treatment specified elsewhere in this paragraph. When the cause is not known, keep the patient lying

down. Do not move him unless absolutely necessary, and then use the utmost care. If he is cold, make him warm. Do not pour liquids into his mouth—this may choke him. Remove from mouth false teeth, chewing gum, or other objects. Take off his equipment. Loosen clothing. Get a medical officer. If the person has merely fainted, he will regain consciousness in a few minutes. Let him lie quietly and apply a wet, cool cloth to his face. If he is about to faint or has actually fainted while sitting up, lower his head between his legs so that blood may flow to his head, holding him so that he cannot fall and injure himself.

7.24 Nuclear Attack

a. Types of Nuclear Explosions. Nuclear explosions are classified according to the height of the burst.

- (1) *Airburst.* A burst in which the fireball does not touch the surface.
- (2) *Surface burst.* A burst in which the fireball does touch the surface.
- (3) *Subsurface burst.* A burst exploded beneath the surface.

b. Effects of Nuclear Explosions.

- (1) *Blast.* The blast effects of a nuclear explosion are comparatively localized and differ from the effects of a high explosive blast only in degree. Damage is caused by direct action of the overpressure and by the secondary action of flying debris, collapsing buildings, etc. The secondary actions cause more injuries to personnel; but the direct action causes more damage

to rigid objects with relatively large surface areas.

- (2) *Heat.* When a nuclear weapon is detonated, the rapid release of energy produces temperatures approaching the interior temperature of the sun. The effects of the heat depend on the height of the burst, the energy yield, and the clarity of the atmosphere. Bare skin can be burned at great distances from the explosion; clothes or any other material which cast shadows give protection. Therefore, a minimum amount of skin area should be exposed. Flash heat starts forest, brush, and other types of fires, while fuel and short-circuits start still others.
- (3) *Radiation.* The explosion of a nuclear weapon produces initial nuclear radiation and may also produce residual nuclear radiation. The initial nuclear radiation is given off in the first minute of the explosion, most of it during the first 2 seconds. If residual nuclear radiation results from the explosion, it is present in the target area immediately following the explosion and may occur in areas downwind of the target area later. The time at which it occurs in those areas depends to a large extent on the speed and direction of the winds through which the particles must pass during their fall to the ground. This type of residual nuclear radiation is commonly referred to as fallout.
- (4) *Relative effects of different types of bursts.*

Type of burst	Blast	Heat	Initial nuclear radiation	Residual nuclear radiation contamination (target area and/or fallout)
Air	Extensive	Extensive	Extensive and hazardous only during explosion.	Negligible, except as induced radioactivity in soil in target area following low airburst.
Surface	Concentrated in smaller area than airburst.	Affects smaller area than does airburst.	Generally less extensive than that from airburst of the same size, but still hazardous.	Generally extensive. Occurs in target area as induced radioactivity in soil and as fallout in target areas and in areas miles downwind of target areas.
Subsurface	Concentrated in a smaller area than airburst or surface burst.	Negligible; most of it is absorbed or deflected by ground or water.	Not considered hazardous	Generally a smaller pattern than a surface burst. Occurs as induced radioactivity in soil and as fallout, just as from a surface burst.

c. Procedures to Follow in a Nuclear Attack.

Before burst	If alert is sounded, follow unit SOP. If warned before explosion, pick strongest shelter you can find in a hurry. Underground shelters, basements, deep foxholes, and tanks give good protection.	
	During and after burst	
During and after burst	1 Take cover	If you see brilliant flash of light brighter than sunlight, dive fast for cover. Fall flat on ground, face down, if shelter is more than a few steps away. Close eyes. Keep head covered. Protect face and hands. Stay down until heavy material has stopped falling.
	2 Stay calm	Be ready for orders and instructions. Help your leaders to reform your unit. Your life and the success of your unit depend on your doing the right thing at the right time.
	3 Continue mission	The nuclear burst is only one part of the enemy's plan. Be ready for more to come. Expect an enemy attack after explosion near your position. Be prepared to attack following an explosion on enemy positions.

d. Special Equipment and Protective Clothing for Use in CBR Decontamination Operations.

Item	Remarks
Helmet-----	Normally worn in all decontamination operations. Protects against falling debris or overhead obstruction.
Soft fatigue cap-----	Protects hair; worn under conditions where other headgear is not required.
Protective hood-----	For use in chemical and biological decontamination and optional for radiological decontamination.
Waterproof parka and trousers.	For use in wet operations.
Heavy jacket and trousers ..	For use during cold weather operations.
Impregnated outer clothing..	For use in chemical decontamination.
Impregnated undershirt-----	For use in chemical decontamination.
Impregnated long drawers...	For use in chemical decontamination.
Impregnated socks-----	For use in chemical decontamination.

Item	Remarks
One-piece coveralls-----	Coveralls (whether impregnated or not) afford better protection against all toxic agents than the shirt or jacket and trousers combinations.
Impermeable protective outfit.	For use in special chemical decontamination and third echelon biological decontamination.
Rubber apron-----	For use in chemical decontamination.
Rubber gloves-----	For use in chemical decontamination and wet operations.
Cotton or canvas gloves----	For use in dry operations biological and radiological).
Impregnated cotton gloves ..	For use in chemical operations.
Boots treated with vesicant gas resistant leather dressing.	For use in chemical decontamination.
Rubber boots-----	For use in chemical decontamination and wet operations.
Protective boot cover-----	For use in special chemical decontamination against inhalation of toxic chemical agents or decontaminants, biological agents, and radioactive dusts.
Protective masks-----	For protection of eyes and for protection against inhalation of toxic chemical agents or decontaminants, biological agents, and radioactive dusts.
Dust respirator-----	For protection against inhalation of radioactive dusts. (The dust respirator filter should be monitored after each use to determine if it should be replaced.)
Other equipment:	
Brushes-----	Scrubbing and brushing.
Shovels-----	Disposal and burial of contaminated objects and materials.
Portable water heater-----	Heating water for decontamination operations.
Hose, fire and garden-----	Hosing and scrubbing operations; also used in bulldozer and road grader operations to keep dust down.
Bulldozers-----	Disposal of contaminated objects; large-scale burial.

Item	Remarks
400-gallon, power-driven, decontaminating apparatus.	Large-scale hosing and spraying operations (large areas, buildings, vehicles, and machinery).
Road graders.....	Scraping away contaminated surfaces.
Chemical service trucks.....	Dipping or disposing of small objects.
Swinging-boom crane trucks..	Dipping or disposing of large objects.
Scrapers, long-handled.....	Paint scraping.
Steam jennies.....	Cleaning greasy or hard-dirt film surfaces and complicated machinery or other equipment.

Item	Remarks
Detection devices:	
AN/PDR-27() radiac set.	Normally 3 per major installation.
IM-9()/PD.....	Normally 1 per individual entering contaminated area.
IM-174/PD.....	Normally 1 per survey party and 3 per major installation.
PP-1578A/PD (detector charger).	Normally 1 per 4 dosimeters.
MX2255/TD holder, film badge (with detecting film).	Normally 1 per individual entering contaminated area.

e. Radiological Decontamination Methods.

Method	Surfaces	Action	Technique	Advantages	Disadvantages
Water washing-----	All nonporous surfaces (metal, paint, plastic). (Not suitable for porous materials such as wood, concrete, and canvas).	Acts as a solvent and erodes. Action faster if water is hot.	For gross decontamination, use water shot from high pressure hose. Work from top to bottom to avoid recontamination and from upwind to avoid spray. Spray from distance of 15 to 20 feet. Use 30° to 45° angle on vertical surfaces. Determine cleaning rate if possible, or use a rate of 4 square feet per minute.	All water equipment may be utilized. Allows operation to be carried out from a distance. Contamination may be reduced by 50 percent. Most readily available agent	Drainage must be controlled. (Runoff is contaminated and requires disposal.) Carries contaminant into porous materials. Not applicable on dry contaminated surfaces (use vacuum) or oiled surfaces.
Using detergent solution.	Nonporous surfaces (especially films).	Emulsifying agent. Wetting agent. (Action faster if solution is hot.)	Rub surface 1 minute and wipe with dry rag; use clean surface of the rag for each application. (Moist application is all that is desired.) Do not allow solution to drip onto other surfaces. Solution may be applied with a powered rotary brush, or from a distance by use of pressure sprays.	Dissolves films which hold contamination. Contamination may be reduced by 90 percent. Easily handled. More efficient than water alone.	Requires close contact with surface. Not efficient for long standing contamination. Runoff requires disposal.
Steaming-----	Nonporous surfaces (especially painted or oiled surfaces.)	Solution and erosion--	Work from top to bottom and from upwind. Clean surface at a rate of 4 feet per minute. The cleaning efficiency of steam may be greatly increased by use of detergents.	Reduces contamination by about 90 percent on painted surfaces.	Runoff requires disposal. Waterproof clothing necessary. Requires special equipment.
Scrubbing-----	Porous and nonporous surfaces.	Physical removal of contaminant.	Use in conjunction with other processes.	Used on "hot spots" following other processes. May be used on small objects and areas.	Slow and laborious. Erosive action on some surface.
Using complexing agents.	Nonporous surfaces...	Forms soluble complexes with contaminant.	Use 3-percent (by weight) solution. Spray solution on surface. Keep surface moist 30 minutes by spraying periodically; then flush with water. 1 gallon of solution decontaminates about 150 sq ft of surface.	Holds contamination in solution. Reduces contamination of unweathered surfaces by 75 percent in 4 minutes. Solution can be prepared in tank of power-driven decontaminating apparatus.	Requires application for 5 to 30 minutes. Little penetrating power. Little value on weathered surfaces.

Using caustic solution: Sodium hydroxide (lye), calcium hydroxide, potassium hydroxide.	Painted surfaces-----	Removes paint-----	Allow solution to remain on surface until paint softens, then wash off with water; remove remaining paint with long-handled scrapers. 1 pound of caustic in 2½ gallons of water removes about 100 sq ft of paint; the addition of 1½ lb of trisodium phosphate aids in removal; the addition of 3 oz of corn starch holds solution to surface.	Time of contact varies with contaminated surface—15 minutes to 2 hours. Can be prepared in steel tank of power-driven decontaminating apparatus.	Can cause severe burns; destroys body tissue. Corrosive to aluminum or magnesium surfaces. Not recommended for vertical or overhead surface.
Using trisodium phosphate solution.	Painted surfaces-----	Removes paint-----	Apply hot 10-percent solution. When paint softens, flush from surface with water. Repeat as necessary.	Reduces activity to tolerance in 1 or 2 applications. Fast acting.	Solution harmful to body tissue. Powder harmful if inhaled. Corrosive to aluminum or magnesium surfaces. Vapors are toxic. Good ventilation required. Fire precautions required.
Using organic solvents: Kerosene, gasoline, alcohol, turpentine, acetone, ether, commercial paint remover.	Nonporous surfaces (greasy or waxed surfaces, paint or plastic finishes).	Dissolves oil and other organic materials. Also removes paint.	Immerse object in solvent or wipe with solvent. Wash in hot soapy water; then rinse in clear water.	Quick dissolving action. Recovery of solvent possible by distillation.	Vapors are toxic. Good ventilation required. Fire precautions required.
Using inorganic acids: Hydrochloric acid, sulfuric acid.	Metal surfaces, especially those with porous deposits rust or calcareous growth); circulatory pipe systems.	Strong dissolving action on metals and porous deposits.	Use dip-bath technique for moveable objects. Keep acid at a concentration of 1 to 2 normal (9- to 18-percent hydrochloric acid, 3- to 6-percent sulfuric acid). (Reaction time on weathered surfaces should be 1 hour; on pipe systems, to 4 hours.) Flush surface with water, neutralize or wash with hot soapy water, and then flush with water again.	Rapid dissolving action-----	Vapors are toxic. (Good ventilation required.) Liquid is harmful to the skin. Acid solutions should not be heated. Rust inhibitor required to prevent corrosion.
Using acid mixtures: Hydrochloric acid or sulfuric acid with acetates or citrates.	Nonporous surfaces, especially those having porous deposits; circulatory pipe systems.	Dissolving action-----	Use same as inorganic acids. Mixtures consist of ¼ ₁₀ gal. hydrochloric acid, ¼ ₁₀ lb sodium acetate, and 1 gal. water. Keep surface wet for 1 hour; then flush with water.	Dissolving action may reduce contamination of unweathered surfaces by 90 percent in 1 hour. Removes rust.	Weathered surface may require prolonged treatment. Harmful to personnel.

Method	Surfaces	Action	Technique	Advantages	Disadvantages
Vacuum blasting-----	Porous and nonporous surfaces.	Physical removal of contaminated surfaces.	Run unit over contaminated surfaces.	Safe and rapid. Contaminant controlled.	Wears away surfaces. Protective mask required.
Sand blasting-----	Nonporous surfaces---	Physical removal of contaminated surfaces.	Wet sand prior to sand-blasting. Keep removed material wetted down.	Satisfactory method for nonporous surfaces. Can be used for large-scale operations.	Wears away surfaces. Not feasible for porous surfaces. Spreads contamination. Protective mask and hood required.
Sanding, filing, grinding, planning, chipping.	Porous and nonporous surfaces.	Physical removal of contaminated surfaces.	Remove surface and control residue.	Reduces "hot spots"-----	Practical for small areas or objects only. Time consuming. Protective mask and gloves required.
Using earthmoving operations.	Soil and loose rock----	Physical removal of contamination.	Remove contamination with bulldozers, road graders, and similar equipment.	Work may begin quickly. Tools or equipment usually available. Reduces hazard quickly (if bulldozers are used).	Limited control of contaminated dust. Disposal problem may become acute. Equipment may become contaminated. Protection mask should be worn.
Brushing-----	Porous and nonporous surfaces.	Physical removal of loose contaminated dust.	Brush dust from surface-----	Work may begin quickly. Rapid action. Brushes usually available.	Limited control of contaminated dust. Little or no removal of dust within pores of many porous surfaces. Protective mask should be worn.
Vacuum cleaning-----	Dry contaminated surfaces.	Removal of contaminated dust by suction.	Use conventional vacuum technique with efficient filter.	Rapid. Good on dry porous surfaces. Water not required. Contamination controlled.	All dust must be removed from exhaust system. Machine may become contaminated. Rubber gloves required for disposal of waste and filters.

f. Radiological Decontamination of Critical Items.

Items	Recommended methods	Equipment or decontaminant	Remarks
Clothing-----	Wash-----	Laundry. (See TM 3-220 and FM 10-3 for details.)	Dispose of water used for washing and rinsing.
	Brushing and shaking----	Brushes.	
Equipment-----	Depends on nature of surface (brushing, washing, aging).	-----	See paragraph 7.26c.
Buildings-----	Abrasion, caustics-----	-----	See paragraph 7.26c.
Terrain-----	Decay-----	None-----	Wait for natural decay.
Water-----	Filter-----	Filters, stills, and purifiers (engineer equipment).	Must be pronounced safe by medical officer or water specialist.
Prepared food in open containers (see below).	Disposal by burial or as directed by medical officer.	Digging equipment.	
Food hot protected in sealed containers.	Scrub or wash, peel-----	Brushes and hose-----	Suspect contamination until monitored. Wash or scrub potatoes and hard-skinned fruits and vegetables; peel or scrape and wash again. Brush visible dirt off meat and fish; pare off thin layer until dose-rate reading is less than 0.1 millirad per hour.
Food in cans or other sealed containers.	Decontaminate container before opening by scrubbing thoroughly.	Brushes, hose, soap-----	Contamination will only affect outer surface of sealed containers. Under no circumstances may cans be opened before decontamination.
Personnel-----	Bathing, scrubbing, showering, washing.	Brushes, hose, showers, soap.	Bathing and scrubbing must be continued until contamination is lowered to a safe level. When showering, hold head back in order to prevent runoff from entering eyes, nose, mouth.

g. Permissible Radiation Dosage. See chapter 7, FM 3-12 and Title 10, part 20, Code of Federal Regulations.

7.25 Biological Attack

a. Precautions.

- (1) Don't pick or eat fruits or berries.
- (2) Don't chew grass or leaves.
- (3) Don't eat native or any other non-U.S.

Armed Forces food or drink; even strong liquor may be contaminated. Boil any suspected water for at least 15 minutes.

- (4) Don't take souvenirs.
- (5) Don't bathe in lakes or ponds or in any water that has not been approved by proper authority.
- (6) Don't touch animals.
- (7) Don't neglect preventive medicine.

b. Procedures to Follow in a Biological Attack.

WHEN	DO THIS	THEN IF	DO THIS
A TOXIC AGENT is suspected— The ALARM sounds— An ATTACK hits your position— for example You are hit by ENEMY BOMBS, SHELLS, or ROCKETS— SPRAY from an AIR-PLANE falls on you— A low CLOUD drifts over you—	HOLD YOUR BREATH. MASK. TAKE COVER—if tactical situation permits. Give the ALARM. DECONTAMINATE—remove wet spots from skin and clothes. CONTINUE MISSION. REMAIN MASKED UNTIL AREA HAS BEEN DECLARED SAFE.	There is no apparent effect on anyone. If later (1 to 10 days), you or your buddies get sick.	CONTINUE MISSION. Observe disease prevention rules; keep wounds and cuts clean; eat and drink only approved food and water. Get medical aid and report sickness.

c. Biological Decontaminants and Their Use.

Decontaminants	Application	Limitations	Remarks
Decontaminating agent, biological, BPL (beta-propiolactone).	Applied as an aerosol or mist from a variety of dissemination devices. One gal. BPL per 16,000 cu ft of space; for rooms with unusual amounts of absorptive surfaces (furnished day rooms or living quarters), 1 gal. per 12,000 cu ft. Recommended conditions are 75° F., relative humidity 70 percent or higher, and 2 hours' contact time. Aeration after decontamination 24 hours. Can be used down to 40° F., but still must have a high humidity.	Toxic to personnel. BPL forms polymers above 3 months' storage, which may be difficult to remove. Corrodes certain metals; adversely affects some plastics (not recommended for decontamination of signal and optical equipment).	Residue formed if excess BPL is used or sprayer is too close to surface. Standard insecticide sprayers recommended.
Formaldehyde solution, USP, 5 parts formaldehyde, 3 parts methanol mixture.	Applied as vapor by heat from standard Army insecticide sprayers or paint-type sprayers, or vaporized by heat or bubbling steam through pan of material. One quart of undiluted formaldehyde solution, or 0.8 quart of formaldehyde-methanol mixture per 1,000 cu ft above 70° F. The amount for each 20° F. drop in temperature should be doubled. Correct time: 16 hours. Aeration after decontamination: 24 hours.	Vapors highly toxic to personnel. Vapors of pure formaldehyde are flammable; open flame not suitable for vaporizing. When steam is used, source of steam should be outside area being decontaminated. Decontamination below 40° F. not advisable. Will not effectively penetrate cloth and similar fabrics. May cause damage to delicate instruments. Dampness may curl and ripple paper. Vapor polymerizes and deposits white powder	Once vaporization has started, even persons wearing masks should not enter area until process is completed. Care must be exercised to prevent leakage of solution during storage. Effective against bacterial toxins (slurry).

Decontaminants	Application	Limitations	Remarks
Ethylene oxide.....	Contaminated equipment should be exposed to vapors in airtight enclosure for 6 hours at 75° F. Thirty lbs ethylene oxide for each 1,000 cu ft of space at 75° F. The amount and contact time for each 20° drop in temperature should be doubled.	on horizontal surfaces; this powder may be washed off with hot water. Handlers required to wear compressed-air or oxygen generating breathing apparatus, masks, rubber gloves, and protective clothing. Requires airtight enclosure to be effective. Highly explosive in most mixtures of air, not suitable for use in buildings. Flammable. Toxic to personnel if improperly used. When ground under enclosure is wet or extremely porous, a protective cover over the ground is required. Decontamination below 50° F. is not advisable. Liquid will damage plastics or leather. Handlers are required to wear compressed-air or oxygen-generating breathing apparatus.	Personnel should wear protective masks during use. Cylinders of ethylene oxide must be protected from rough handling and sparks and stored away from fire. Vapor highly penetrating but noncorrosive.
Carboxide.....	Contaminated equipment should be exposed for 12-24 hours in airtight enclosure. Sixty lb per 1,000 cu ft of space above 80° F. For each 20° drop in temperature the amount should be doubled.	Not as effective as ethylene oxide. Requires airtight enclosure to be effective. Toxic to personnel. Decontamination below 50° F is not advisable. Handlers are required to wear compressed-air to oxygen-generating breathing apparatus in the decontaminating area.	Carboxide is noncorrosive Packaged commercially in 60-lb cylinders. Nonflammable.
Methyl bromide.....	Items should be exposed to vapors for 12 hours in quarter-master delousing bags; 5 ampules per bag. Aeration time should be at least 2 hours.	Vapors are highly toxic. Should not be used in closed spaces where odorless vapors could accumulate.	Noncorrosive to metals and nonflammable.
STB (supertropical bleach).	For horizontal surfaces, slurry of 13 parts STB to 87 parts water should be used; for vertical surfaces, 40 parts STB to 60 parts water, preferably from a power-driven decontaminating apparatus. Average coverage: 1 gal. per 8 sq yd for porous surfaces such as concrete and ½ gal. per sq yd for closely packed surfaces.	Corrosive to metals. Should not be inhaled or come in contact with skin. Protective mask should be worn when preparing slurries.	In ordinary storage, loss of available chlorine is less than 1 percent per month. When free chlorine falls below 10 percent, bleach should be salvaged. As available free chlorine is lost, STB content must be increased. Should be stored in unheated warehouse isolated from combustibles and metals subject to corrosion.

Decontaminants	Application	Limitations	Remarks
DANC solution.....	Applied to surfaces with brushes, brooms, or swabs. Residue should be washed from surfaces with hot soapy water; then rinsed with clear water. Metal surfaces should be oiled and dried.	Highly toxic. Should not be inhaled or come in contact with skin. Protective mask and clothing and rubber gloves should be worn when applying. Will soften paint, rubber, and plastics.	Contains about 30-percent available chlorine when fresh. Contents of white powder (RH195) must be mixed with solvent (acetylene tetrachloride) just prior to use.
Decontaminating agent, DS2.	Applied to surfaces with brushes, brooms, or swabs; or sprayed from M11 apparatus. Surfaces should be flushed after 30 minutes with water.	Flammable. Should not come into contact with skin. Must be removed from skin and metals. Ineffective against spore formers.	Packaged ready for use in 5-gal. drums or 1½ qt containers (refill for M11 apparatus). Effective against most spore formers; noncorrosive to most metals.
Calcium hypochlorite, HTH (70-percent available chlorine).	A slurry of 7 parts HTH and 93 parts water can be used for horizontal surfaces. Coverage same as STB.	HTH is highly corrosive to metal; cannot be used in power-driven decontaminating apparatus. Loses chlorine content rapidly. Should not be inhaled or come in contact with skin and eyes. Protective mask should be worn when preparing slurries.	Packaged in 5-lb cans and 100-lb drums. Contains about 70-percent available chlorine when packaged.
Sodium hypochlorite (household bleach).	Applied (undiluted) with brooms, brushes, or swabs, or sprayed from power-driven decontaminating apparatus. Should be diluted for cotton clothing (½ cup to 1 gal. water). Coverage same as for STB and HTH.	Undiluted, it is harmful to skin and clothing. Corrosive to metals unless rinsed and protected after decontamination.	Removed from skin and clothing by flushing with large amounts of water. Contains about 5-percent available chlorine. Must be stored in cool place.
Caustic soda or lye (sodium hydroxide).	Ten-percent solution, by weight, should be used. Average application: ½ gal. per sq yd on horizontal surfaces.	Corrosive to skin, eyes. Five-percent solution will deteriorate wool and cotton. Highly corrosive to most metals. Solution should not be mixed in aluminum, tin, or zinc containers.	Should be removed immediately from skin and eyes. Caustic soda solution may be kept in iron, steel, or glass containers equipped with rubber stoppers, wired or taped in place when not in use.

7.26 Chemical Attack

a. Procedures to Follow in a Chemical Attack.
The most important single item of equipment the soldier has for defense against chemical attack is his protective mask. It must be carried at all times, since nothing else can do its job. It should

be inspected often, and the valves should be kept clean. All rubber parts must be kept away from POL products, and water must not enter the canister. The mask should never be sat on or have any heavy objects placed upon it. Procedures as follows:

WHEN	DO THIS	THEN IF	DO THIS	
A TOXIC AGENT is suspected—	HOLD YOUR BREATH.	Your nose starts running suddenly—	Give yourself one atropine shot ¹ and fasten used tube on shirt or jacket pocket. CONTINUE MISSION.	NERVE AGENT
The ALARM sounds—	MASK.	Your chest feels tight—		
AN ATTACK hits your position— for example	Take COVER . . . if tactical situation permits.	Your eyesight gets dim—		
		Breathing becomes difficult—		
	GIVE ALARM.	Your buddy: has difficulty breathing—	Mask your buddy and give him the atropine shot ¹ if he has not taken it. CONTINUE MISSION.	BLISTER AGENT
You are hit by ENEMY BOMB SHELLS, or ROCKETS—	DECONTAMINATE . . . remove wet spots from skin ² and clothes.	slobbers, sweats, or vomits—		
		twitches, jerks, or staggers, or has pinpointed pupils—		
SPRAY from an AIR-PLANE falls on you.	CONTINUE MISSION.			
A low CLOUD drifts over you.	REMAIN MASKED UNTIL AREA HAS BEEN DECLARED SAFE.	Your buddy: has great difficulty getting his breath or stops breathing—	Same as above, BUT ALSO give him ARTIFICIAL RESPIRATION. CONTINUE MISSION.	BLOOD AGENT
		If liquid agent gets in eyes or face—	Flush eyes with water and decontaminate skin. ² CONTINUE MISSION.	
		You have wet spots on skin or clothes—	Cut away spots and rub skin with protective ointment. ² CONTINUE MISSION.	
		You begin breathing rapidly or gasping for air—	Move to fresh air if possible. Inhale amyl nitrite inserted inside mask.	CHOKING AGENT
		You cough or choke. Your chest becomes tight—	Loosen clothing. CONTINUE MISSION. If shortness of breath occurs, keep warm and quiet.	

¹ To give atropine shot: (a) Remove needle cover, taking care to keep wire loop in place. (b) Push wire through seal, keeping needle end up. Gently squeeze tube until one drop of liquid appears at end of needle. Pull wire out and discard. (c) Push needle deep into thigh muscle, injecting through clothing. (d) Squeeze tube empty. Massage area for quick effect. (e) Stick needle through pocket and bend it into a hook to fasten securely. USE ATROPINE ONLY IN NERVE AGENT POISONING. Continue giving atropine at 10 minute intervals if symptoms persist. The officer or noncommissioned officer in charge will tell you when to give more than 3 injections.

² To decontaminate skin: (a) Pinch-blot agent from skin. (b) Flush area with water. (c) Rub on protective (M-5) ointment. (d) Wipe off ointment. (e) Rub on second coat of ointment—let it stay. (f) If after masking you suspect that agent is on your face, take a deep breath and hold it, then raise mask and perform steps (a) through (e) again. Reseat and clear mask. Keep ointment away from eyes.

b. Chemical Decontamination Methods.¹

Contaminated surface or object	Preferred decontamination method	Alternate decontamination methods	Field expedient methods
Asphalt: Roads ² -----	Flush with water----- Spray with slurry from	Cover with STB; when liquid contaminant is visible	Weather. Cover small areas or paths

See footnotes at end of table.

Contaminated surface or object	Preferred decontamination method	Alternate decontamination methods	Field expedient methods
Roof -----	power-driven contaminating apparatus. Flush with water. Spray with slurry from power-driven decontaminating apparatus.	ble and personnel are nearby, use dry mix. Cover with STB or dry mix.	across roads with 4 inches of earth. Weather.
Brick and stone: Roads ² -----	Spray with slurry from power-driven decontaminating apparatus or apply with brushes and brooms. Let remain 24 hours before flushing.	Wash with soapy water, preferably hot.	Cover small areas or paths across roads with 4 inches of earth. Weather.
Buildings -----	Spray with slurry from power-driven decontaminating apparatus or apply with brushes and brooms. Let remain 24 hours, then flush with water.	Wash with soapy water, preferably hot. Use STB or dry mix around buildings, where waste water runs.	Weather.
Canvas: Tarpaulin, tentage, covers, mask carriers, cartridge belts.	Immerse in boiling soapy water for 1 hour. Use 5-percent solution of sodium hypochlorite (household bleach) for V-agents. Use 5-percent solution of washing soda for G-agents.	Immerse in boiling water for 1 hour. Launder by standard methods. (Refer to pertinent QM publications.) Use DANC solution or DS2. Use slurry.	Aerate (except for V-agents).
Concrete: Roads ² ----- Buildings, pillboxes, gun emplacements, tank obstacles.	Spray with slurry from power-driven decontaminating apparatus. Spray with slurry from power-driven decontaminating apparatus or apply with brushes and brooms. Let remain 24 hours; then flush with water.	Cover with STB or dry mix. Wash with soapy water, preferably hot. Apply STB or dry mix on ground surrounding structure where waste water flows.	Weather. Cover small areas or paths across roads with 4 inches of earth. Cover small areas with 4 inches of earth, if practicable.
Earth: Roads ² , gun emplacements, bivouac areas, pathways, bomb craters.	Spray with slurry from power-driven decontaminating apparatus.	Cover with STB or, when liquid contaminant is visible and personnel are nearby, use dry mix.	Weather. Burn. Cover small areas or paths across roads with 4 inches of earth. Scrape layer of contaminated earth to side of road.
Leather: Boots, gloves, and other items.	Scrub with hot soapy water and rinse. Immerse in soapy water at 120° F. for 4 hours and rinse.	Immerse in a 5-percent solution of sodium hypochlorite for V-agents. Use 5-percent washing soda solution for G-agents.	Aerate.
Fabrics (cotton or wool ³): Coveralls, shirts, trousers, field jackets, underwear, socks, gloves, overcoats, ties, hoods, barracks bags.	<i>For Cotton Items</i> Immerse in boiling water for 1 hour; stir items; add 1 lb soap to 10 gal. water to make water alkaline. Use 5-percent solution of sodium hypochlorite (bleach) for V-agents. Use 5-percent solution of washing soda for V-agents.	Launder by standard methods. (Refer to pertinent QM publications.) Dryclean. Use DS2 for cotton items only.	Rub M5 protective ointment on small contaminated areas. Aerate except for V-agents.

Contaminated surface or object	Preferred decontamination method	Alternate decontamination methods	Field expedient methods
	<i>For Woolen Items</i> Extract with solvent. Immerse in warm (100° F.) soapy water for 1 hour or longer with light agitation; dry items slowly.		
Glass:			
Windows-----	Use 5-percent solution of sodium hypochlorite for V-agents. Spray with DS2 or DANC solution.	Wash with hot soapy water. Wash with clear water or organic solvent.	Blot off surface. Aerate. Weather.
Lenses-----	Use 5-percent solution of sodium hypochlorite for V-agents. Spray with DS2 or DANC solution.	Wash with hot soapy water. Wash with clear water or organic solvent.	Blot off surface. Aerate.
Grass and low vegetation (fields, open terrain). ²	Burn----- Spray with slurry from power-driven decontaminating apparatus.	Cover with STB or dry mix--	Burn. Explode drums of STB decontaminating agent. Clear paths through area by use of detonating cord or other detonating devices.
Metals (unpainted):			
Ammunition-----	Use DS2 or DANC solution; then rinse or wipe with organic solvent and dry.	Wash with cool soapy water and rinse.	Aerate.
Machinery-----	Spray with DANC solution or DS2 and rinse.	Wash with hot soapy water. Wash with organic solvent.	Weather. Aerate.
Mess gear, canned rations.	Immerse in boiling soapy water for 30 minutes and rinse. Immerse in boiling water for 30 minutes.	Spray with DS2 or DANC solution and rinse. Wash in hot soapy water, rinse, and aerate.	
Metals (painted): ⁴			
Vehicles, weapons, equipment.	Spray with DS2 or DANC solution.	Wash with hot soapy water and rinse. (Slurry may be used if it is removed from surface, oiled.)	Aerate. Weather.
Plastics ⁵ (opaque): Insulation, telephones, panel boards.	Spray with DS2 or DANC solution and rinse.	Wash with hot soapy water and rinse. Wipe with organic solvent and then rinse.	Weather. Aerate.
Plastics ⁵ (transparent):			
Eyepieces-----	Spray with DS2 and rinse--	Wash with hot soapy water. Wipe with organic solvent and aerate.	Aerate.
Airplane canopies-----	Spray with DS2 and rinse--	Wash with hot soapy water. Wipe with organic solvent and aerate.	Weather.
Rubber (impermeable):			
Aprons, suits, and other items.	Spray with DS2 and rinse after 30 minutes. Immerse in hot soapy water (just below boiling point) for 1 hour; do not agitate. Rinse with clear water and hang up to dry.	Apply hot soapy water with brushes and rinse. Spray with slurry from power-driven decontaminating apparatus. After a few minutes, wash off with clear water.	Aerate. Weather.

See footnotes at end of table.

Contaminated surface or object	Preferred decontamination method	Alternate decontamination methods	Field expedient methods
	For G-agents, use 10-percent washing soda solution, rinse off, and aerate.		
Rubber (natural and synthetic):			
Gloves, boots-----	Spray with DS2 and rinse... Immerse in slurry solution for 4 hours, rinse off and aerate.	Immerse in hot soapy water for 2 to 8 hours; do not boil more than 4 times a year.	Apply M5 protective ointment immediately. Aerate.
Mask facepieces, and other rubber articles coming in direct contact with the skin.	Spray with DS2 and rinse...	Immerse in hot soapy water for 6 to 8 hours for heavy contamination and 3 hours for moderate contamination. Do not boil more than 4 times a year.	Apply M5 protective ointment immediately. (Apply to both sides of mask facepieces.)
Tires, hose, mats, insulation.	Spray with DS2 and rinse... Apply thick slurry, allow slurry to remain at least 30 minutes, then flush with clear water. (May be left on tires.)	Immerse in water for 2 to 3 hours; do not boil more than 4 times a year.	Aerate. Weather.
Sand ² (beaches, deserts)-----	Flush with water-----	Spread STB or slurry over surface.	Weather. Cover paths with roofing paper. Scrape off 2 to 3 inches of contaminated top layer.
Undergrowth and tall grass (meadows, jungles, forests). ²	Burn-----	Spray slurry from power-driven decontaminating apparatus.	Weather. Explode drums of STB. Clear paths with detonating cord, bangalore torpedoes, or demolition snakes.
Wood:			
Buildings, vehicle bodies.	Apply slurry with power-driven decontaminating apparatus, brooms, or swabs. Let slurry remain 12 to 24 hours; flush and repeat application; then flush again.	Scrub with hot soapy water and rise.	Weather.
Boxes, crates, gunstocks.	Apply slurry with power-driven decontaminating apparatus, brooms, or swabs. Let slurry remain 12 to 24 hours; flush and repeat application, then flush again. (Scrub slurry off gunstocks with soapy water and rinse.)	Scrub with hot soapy water and rinse.	Weather.
Wood (painted surface): ⁴			
Buildings, boxes-----	Apply slurry with power-driven decontaminating apparatus, brooms, or swabs. Let slurry remain 12 to 24 hours, then rinse off with water.	Scrub with hot soapy water and rinse. Use DS2 and rinse.	Weather.

¹ DANC is not recommended for G-agent decontamination; 10-percent alkaline solutions are recommended for G-agent decontamination on material except fabrics to include canvas and leather.

² Applicable to small vital areas only.

³ DS2 is not recommended for woolen items.

⁴ DS2 may soften fresh paint.

⁵ DS2 and DANC solution are destructive to plastics if not rinsed from them.

Section VII. POL CONTAINERS AND PIPELINES

7.27 Pipeline Estimates

a. Rate of Discharge. The quantity of fluid passing through a pipe in a unit of time is termed the capacity or rate of discharge of the pipe and may be determined from the equation

$$Q = A \times V$$

where

Q = rate of discharge in cubic feet per second

A = cross-sectional area of the pipe in square feet

V = mean velocity of fluid in feet per second

- (1) If the rate of discharge is given in terms of U.S. gallons, these may be converted to cubic feet by multiplying the given number of gallons by 0.13368. Cubic feet may be converted to U.S. gallons by multiplying the number of cubic feet by 7.4805.
- (2) The cross-sectional area of the pipe in square feet is determined by using the equation

$$A = 0.7854D^2$$

where

A = cross-sectional area of the pipe in square feet

D = inside diameter of the pipe in feet

- (3) The mean velocity of a fluid varies according to the size, hydraulic gradient, and physical condition of the pipe through which it flows. Economical pipeline velocities are ordinarily in the range of 3.5 to 5.5 feet per second.

b. Example. Determine the rate of discharge of an 8-inch pipeline in which gasoline is flowing at a velocity of 3 miles per hour.

$$D = 8/12 \text{ or } 0.67 \text{ foot}$$

$$A = 0.7854 \times (0.67)^2 = 0.3525 \text{ square foot}$$

$$3 \text{ mph} = \frac{3 \text{ mph} \times 5,280 \text{ feet per mile}}{60 \text{ minutes per hour}}$$

$$= 264 \text{ feet per minute}$$

$$264 \text{ feet per minute} \times 0.3525 \text{ square foot} = 93.1 \text{ cubic feet per minute}$$

$$93.1 \text{ cubic feet per minute} \times 7.4805 \text{ gallons per cubic foot} = 696.43 \text{ gallons per minute.}$$

c. Increasing Capacity. The volume of liquid which can be transported through a given pipeline

may be increased by longer operation and/or increased pressure. These methods may be used individually or in combination; however, they should be used only on a short-term basis. If increased capacity is desired over a considerable period of time, it is usually better to construct an additional pipeline.

(1) *Hours of operation.* Normal capacity of a pipeline is based on an operating time of 20 hours per day.

(2) *Differential pressure.* Increasing the differential pressure of all pumping stations increases the capacity of a given pipeline. To increase the differential pressure of a pumping station increase the differential pressure on each pump in the pumping station and/or the number of pumps operating in series at the pumping station.

d. Capacity of Standard Military Light-Weight Steel Tubing.

Inside diameter of line (in.)	Normal design capacity (bbl per yr)	Emergency capacity (bbl per hr)	Safe working pressure (psi)	Maximum working pressure (psi)	Gallons per day*	Short tons per day
4.35	355	393	600	750	294,000	930
6.415	785	1,000	600	750	630,000	2,000
8.415	1,355	1,730	500	600	1,135,000	3,500
12.481	7,150	11,400	400	530	6,000,000	18,000

* Computed for an average of all products at normal design capacity, using a 20-hour operating day.

e. Capacity of Pipes and Cylindrical Conduits. The formula below is used to determine the number of gallons per 12 inches of pipe or cylindrical conduit length. Measurements are in inches. Gallons per foot of length

$$= \frac{(3.1416)(\text{pipe or conduit radius})^2 (12)}{231}$$

$$= \frac{(9.4248)(\text{diameter})^2}{231}$$

$$= (.0408)(\text{diameter})^2$$

The table in paragraph 7.28 (1) (b) is applicable here if the vertical cylindrical tank is considered to be in a horizontal position, for then the gallons per foot of liquid depth in the table have the same meaning as gallons per foot of length for full pipes and cylindrical conduits on the ground. To obtain gallons per minute, multiply velocity of flow in feet per minute by the figure shown.

f. Proper Sizes for Pipes. To determine the proper diameter of a pipe for gases and liquids, use the formula in (2) below. Determine the weight of the fluid (in pounds per cubic foot) and the weight of the fluid to flow in the pipe (in thousands of pounds per hour). Then use logarithmic computations to solve the fractional powers of F and d (par. 7.59). Weights indicated below are for normal atmospheric pressure (14.7 psi) and a temperature of 60° F. Variations in pressure and temperature cause the figures for gases to vary considerably, but, for the purposes of this subparagraph, changes in temperature can be disregarded. The actual pressure in the line is the principal determining factor for fluid density, since the unit of volume remains constant. Pressure changes for gases can be compensated for by multiplying $\frac{P}{14.7}$ by the unit weights shown below. In this formula, P is the actual pressure in the line.

(1) *Weights of liquids and gases.*

Fluid in pipeline	Pounds per cu ft
Liquids:	
Aviation gasoline.....	44.1
91A gasoline.....	45.7
Kerosene.....	50.8
Diesel oil.....	52.3
Lubricating oil.....	56.8
Water, fresh.....	62.4
Water, sea.....	64.0
Gases:	
Air.....	0.07658
Ammonia.....	0.04509
Benzene.....	0.20640
Butane.....	0.15350
Carbon dioxide.....	0.11637
Chlorine.....	0.18750
Ethylene.....	0.07410
Helium.....	0.01058
Hydrogen.....	0.00530
Methane.....	0.04234
Natural gas.....	0.05140
Oxygen.....	0.08463
Propane.....	0.11645
Steam.....	0.04761

(2) *Formula.*

$$D = 2.2 \times \frac{F^{0.45}}{d^{0.31}}$$

Where

D = diameter of pipe in inches
 F = calculated flow for the pipeline in thousands of pounds per hour.
 d = density of the fluid to flow in the pipe in pounds per cubic foot

g. Data for Steel Pipe. The figures shown below can be used by the transportation planner for loading and transporting pipe and for computing volumes and weights of the fluid transported in pipes over a specified period of time. The figures in column 2 are expressed in feet so they can be squared and multiplied by 3.1416 to obtain the unit capacity shown in column 3. Inside radii in column 2 vary for the common pipe sizes, depending upon the amount of pressure the line is to carry. (A smaller diameter indicates a heavier pipe, capable of greater pressure.) To arrive at the total cubic feet per second, multiply the figures in column 3 by the actual flow in feet per second in the line. Convert to U.S. gallons per second by multiplying by 7.481, or to U.S. gallons per minute by multiplying by 448.86. Pressure and, therefore, velocity can be built up to the rated capacity of the pipe and pumping system. Data in columns 4 and 5 can be used by the planner for the loading and transporting of steel pipe.

Common pipe size (in.)*	Actual inside radius (ft)	Capacity in cubic feet per second at a flow (velocity) of 1 ft per sec	Weight of 100 ft of pipe (lb)	Outside diameter of pipe (ft)
1	2	3	4	5
1/8	.01120	.000395	26.3	.0337
1/8	.00896	.000243	33.6	.0337
1/4	.01516	.000720	45.2	.0450
1/4	.01266	.000504	56.7	.0450
3/8	.02054	.001330	59.8	.0562
3/8	.01760	.000974	77.7	.0562
1/2	.0259	.00211	89.3	.0700
1/2	.0227	.00162	114.5	.0700
1/2	.0194	.00118	137.6	.0700
3/4	.0344	.00372	118.7	.0875
3/4	.0309	.00300	155.4	.0875
3/4	.0256	.00206	203.7	.0875
1	.0437	.00598	176.4	.1095
1	.0398	.00497	227.9	.1095
1	.0340	.00363	299.3	.1095
1 1/4	.0575	.01038	239.4	.1385
1 1/4	.0533	.00892	315.0	.1385
1 1/4	.0483	.00733	395.9	.1385
1 1/2	.0671	.01410	285.6	.1582
1 1/2	.0625	.01225	382.2	.1582
1 1/2	.0558	.00977	510.3	.1582
2	.0862	.0233	384.3	.1980
2	.0808	.0205	528.2	.1980
2	.0704	.0156	782.3	.1980
2 1/2	.1030	.0333	609.0	.2395
2 1/2	.0967	.0294	805.4	.2395
2 1/2	.0886	.0246	1,050	.2395
3	.1280	.0514	795.9	.2915
3	.1210	.0460	1,082	.2915

* Does not necessarily indicate the pipe is actually this size.

Common pipe size (in.)*	Actual inside radius (ft)	Capacity in cubic feet per second at a flow (velocity) of 1 ft per sec	Weight of 100 ft of pipe (lb)	Outside diameter of pipe (ft)
1	2	3	4	5
3	.1097	.0379	1,502	.2915
3½	.1480	.0688	956.6	.333
3½	.1405	.0621	1,313	.333
4	.1680	.0886	1,134	.375
4	.1596	.0801	1,575	.375
4	.1510	.0716	1,995	.375
4	.1435	.0647	2,370	.375
5	.2102	.1390	1,544	.463
5	.2002	.1263	2,184	.463
5	.1896	.1130	2,846	.463
5	.1795	.1013	3,465	.463
6	.2524	.2000	1,995	.552
6	.2400	.1810	3,003	.552
6	.2290	.1650	3,822	.552
6	.2163	.1470	4,757	.552
8	.3390	.3605	2,352	.719
8	.3361	.3550	9,594	.719
8	.3325	.3470	3,003	.719
8	.3251	.3320	3,749	.719
8	.3180	.3178	4,557	.719
8	.3100	.3020	5,385	.719
8	.2995	.2820	6,374	.719
8	.2915	.2673	7,119	.719
8	.2832	.2525	7,844	.719
10	.4270	.5730	2,951	.896
10	.4230	.5625	3,602	.896
10	.4180	.5500	4,253	.896
10	.4060	.5170	5,754	.896
10	.3980	.4970	6,762	.896
10	.3872	.4710	8,085	.896
10	.3770	.4460	9,366	.896
10	.3650	.4185	11,025	.896
10	.3540	.3930	12,180	.896
12	.5110	.8190	3,507	1.062
12	.5040	.7980	4,599	1.062
12	.4980	.7790	5,628	1.062
12	.4840	.7365	7,686	1.062
12	.4720	.7060	9,303	1.062
12	.4615	.6680	11,340	1.062
12	.4480	.6310	13,230	1.062
12	.4380	.6030	14,700	1.062
12	.4225	.5610	16,905	1.062
14	.5625	.9950	3,864	1.167
14	.5575	.9790	4,799	1.167
14	.5520	.9575	5,733	1.167
14	.5470	.9400	6,647	1.167
14	.5340	.8950	8,925	1.167
14	.5210	.8520	11,235	1.167
14	.5060	.8030	13,755	1.167
14	.4940	.7675	15,435	1.167
14	.4790	.7220	17,955	1.167
14	.4670	.6850	20,350	1.167
16	.6460	1.310	4,421	1.333
16	.6420	1.293	5,492	1.333
16	.6350	1.265	6,573	1.333

* Does not necessarily indicate the pipe is actually this size.

Common pipe size (in.)*	Actual inside radius (ft)	Capacity in cubic feet per second at a flow (velocity) of 1 ft per sec	Weight of 100 ft of pipe (lb)	Outside diameter of pipe (ft)
1	2	3	4	5
16	.6250	1.227	8,694	1.333
16	.6120	1.176	11,340	1.333
16	.5970	1.120	14,385	1.333
16	.5810	1.058	17,325	1.333
16	.5650	1.002	20,265	1.333
16	.5470	.940	23,520	1.333
16	.5365	.902	25,305	1.333
18	.7290	1.667	4,977	1.500
18	.7240	1.648	6,695	1.500
18	.7140	1.602	8,610	1.500
18	.7025	1.550	11,025	1.500
18	.6905	1.497	13,965	1.500
18	.6725	1.420	17,955	1.500
18	.6530	1.341	21,840	1.500
18	.6380	1.280	25,095	1.500
18	.6200	1.208	28,875	1.500
18	.6035	1.145	31,920	1.500
20	.8130	2.074	5,544	1.665
20	.8025	2.025	8,253	1.665
20	.7910	1.965	11,025	1.665
20	.7835	1.931	12,915	1.665
20	.7660	1.840	17,535	1.665
20	.7480	1.757	21,945	1.665
20	.7290	1.670	26,355	1.665
20	.7080	1.573	31,385	1.665
20	.6875	1.484	35,910	1.665
20	.6725	1.420	39,270	1.665
24	.9795	3.015	6,668	2.000
24	.9680	2.945	9,944	2.000
24	.9520	2.845	14,805	2.000
24	.9440	2.803	17,955	2.000
24	.9230	2.673	24,255	2.000
24	.8980	2.532	31,185	2.000
24	.8750	2.408	37,905	2.000
24	.8540	2.290	43,680	2.000
24	.8285	2.155	50,820	2.000
24	.8080	2.052	56,280	2.000
30	1.225	4.720	10,395	2.500
30	1.207	4.575	16,590	2.500
30	1.198	4.510	20,685	2.500

* Does not necessarily indicate the pipe is actually this size.

7.28 Volume of Liquid in Tanks

a. General. Transportation planners and users frequently need weight and cube data for liquids. After a volume of liquid has been determined, the weight may be found by multiplying the total volume in gallons by the weight of 1 gallon of the liquid. (Unit weights for various liquids are to be found elsewhere in this manual.) It is assumed that the cylindrical and elliptical tanks discussed below have flat ends. (If a tank does not have flat ends, then the curvature of the ends must be

determined, and the volume contained in the ends added to the volumes shown below. However, in such cases, it is usually more advantageous to calibrate the tank, which entails the drawing off or adding of measured amounts of the liquid and measuring the change in liquid depth in the tank.) In the tables below, single and/or double interpolation should be used to determine values in between those shown. Values shown are close approximations for 60° F. and can be used for practical purposes. Variations in conditions, especially temperature, cause the values to vary. If exact quantities are desired, the formulas shown must be used in conjunction with temperature coefficients of expansion and contraction for the liquids and containers. Presentation of detailed computations for varying conditions is not within the scope of this manual, but approximate computations for POL products under various temperatures are shown in *f* below.

Unless otherwise specified, dimensions are in inches.

b. Cylindrical Tanks.

(1) *Vertical.*

- (a) *Formula.* The volume of liquid in a vertical cylindrical tank may be computed by using the formula shown below.

$$\begin{aligned} \text{Gallons per foot of liquid depth} &= \frac{(3.1416)(\text{radius of tank})^2 (12)}{231} \\ &= \frac{(9.4248)(\text{diameter of tank})^2}{231} \\ &= (.0408)(\text{diameter})^2 \end{aligned}$$

- (b) *Table.* Gallons per foot of liquid depth are shown for vertical cylindrical tanks of various diameters.

Diameter (in.)	Gallons per ft	Diameter (in.)	Gallons per ft	Diameter (in.)	Gallons per ft	Diameter (in.)	Gallons per ft	Diameter (in.)	Gallons per ft
1	0.0408	38	58.90	75	229.8	112	512.5	149	906.0
2	0.163	39	62.00	76	236.0	113	522.0	150	917.0
3	0.367	40	65.30	77	242.2	114	532.5	151	930.0
4	0.653	41	68.60	78	248.7	115	541.0	152	942.0
5	1.02	42	71.90	79	255.0	116	551.0	153	955.0
6	1.47	43	75.40	80	261.2	117	560.0	154	968.0
7	2.00	44	79.00	81	268.0	118	570.0	155	979.0
8	2.61	45	82.60	82	274.8	119	580.0	156	993.0
9	3.30	46	86.30	83	281.0	120	589.0	157	1,005
10	4.08	47	90.10	84	288.0	121	597.0	158	1,018
11	4.93	48	93.90	85	295.3	122	607.0	159	1,031
12	5.87	49	97.90	86	302.0	123	617.0	160	1,044
13	6.89	50	102.0	87	309.0	124	627.0	161	1,058
14	8.00	51	106.0	88	316.8	125	637.0	162	1,070
15	9.17	52	110.1	89	323.5	126	648.0	163	1,082
16	10.44	53	114.6	90	331.0	127	658.0	164	1,096
17	11.78	54	118.9	91	338.0	128	668.0	165	1,110
18	13.22	55	123.3	92	346.0	129	679.0	166	1,122
19	14.72	56	127.9	93	353.6	130	689.0	167	1,137
20	16.31	57	132.8	94	361.0	131	698.0	168	1,151
21	18.00	58	137.4	95	369.0	132	710.0	169	1,165
22	19.75	59	142.2	96	377.0	133	722.0	170	1,178
23	21.60	60	147.1	97	384.5	134	733.0	171	1,193
24	23.50	61	152.1	98	392.5	135	743.0	172	1,205
25	25.50	62	157.0	99	401.0	136	754.0	173	1,219
26	27.56	63	162.0	100	408.5	137	766.0	174	1,235
27	29.79	64	167.5	101	417.0	138	777.0	175	1,247
28	32.00	65	172.5	102	426.0	139	788.0	176	1,263
29	34.33	66	177.7	103	434.0	140	800.1	177	1,278
30	36.65	67	183.3	104	442.5	141	811.0	178	1,293
31	39.20	68	188.3	105	451.0	142	822.0	179	1,309
32	41.80	69	194.5	106	459.0	143	833.0	180	1,322
33	44.40	70	200.0	107	467.5	144	846.0	181	1,336
34	47.20	71	206.0	108	477.5	145	858.0	182	1,347
35	49.90	72	211.9	109	486.0	146	871.0	183	1,365
36	52.80	73	217.5	110	495.0	147	882.0	184	1,380
37	55.80	74	223.6	111	503.0	148	893.0	185	1,395

Diameter (in.)	Gallons per ft	Diameter (in.)	Gallons per ft	Diameter (in.)	Gallons per ft	Diameter (in.)	Gallons per ft	Diameter (in.)	Gallons per ft
186	1,411	243	2,409	300	3,665	356	5,180	650	17,250
187	1,425	244	2,429	301	3,690	357	5,210	660	17,770
188	1,442	245	2,449	302	3,720	358	5,240	670	18,330
189	1,459	246	2,469	303	3,748	359	5,270	680	18,880
190	1,472	247	2,489	304	3,770	360	5,280	690	19,450
191	1,486	248	2,509	305	3,800	365	5,440	700	20,000
192	1,504	249	2,530	306	3,820	370	5,580	710	20,600
193	1,520	250	2,550	307	3,850	375	5,740	720	21,190
194	1,537	251	2,571	308	3,880	380	5,890	730	21,750
195	1,553	252	2,590	309	3,900	385	6,060	740	22,360
196	1,566	253	2,610	310	3,920	390	6,200	750	22,980
197	1,580	254	2,630	311	3,950	395	6,370	760	23,600
198	1,600	255	2,650	312	3,970	400	6,530	770	24,220
199	1,618	256	2,672	313	4,000	405	6,700	780	24,870
200	1,631	257	2,694	314	4,030	410	6,860	790	25,500
201	1,648	258	2,717	315	4,050	415	7,030	800	26,120
202	1,666	259	2,734	316	4,080	420	7,190	810	26,800
203	1,680	260	2,756	317	4,110	425	7,380	820	27,480
204	1,697	261	2,780	318	4,130	430	7,540	830	28,100
205	1,714	262	2,800	319	4,160	435	7,730	840	28,800
206	1,733	263	2,819	320	4,180	440	7,900	850	29,530
207	1,748	264	2,844	321	4,210	445	8,080	860	30,200
208	1,766	265	2,862	322	4,230	450	8,260	870	30,900
209	1,781	266	2,890	323	4,260	455	8,450	880	31,680
210	1,800	267	2,909	324	4,280	460	8,630	890	32,350
211	1,819	268	2,930	325	4,310	465	8,830	900	33,100
212	1,836	269	2,950	326	4,340	470	9,010	910	33,800
213	1,851	270	2,979	327	4,360	475	9,200	920	34,600
214	1,870	271	2,992	328	4,390	480	9,390	930	35,360
215	1,884	272	3,018	329	4,420	485	9,600	940	36,100
216	1,902	273	3,039	330	4,440	490	9,790	950	36,900
217	1,920	274	3,061	331	4,470	495	10,000	960	37,700
218	1,940	275	3,085	332	4,500	500	10,200	970	38,450
219	1,957	276	3,110	333	4,530	505	10,400	980	39,250
220	1,975	277	3,125	334	4,550	510	10,600	990	40,100
221	1,991	278	3,150	335	4,580	515	10,810	1,000	40,850
222	2,010	279	3,180	336	4,610	520	11,010	1,010	41,700
223	2,025	280	3,200	337	4,630	525	11,240	1,020	42,600
224	2,050	281	3,220	338	4,670	530	11,460	1,030	43,400
225	2,065	282	3,244	339	4,690	535	11,670	1,040	44,250
226	2,083	283	3,265	340	4,720	540	11,890	1,050	45,100
227	2,100	284	3,288	341	4,740	545	12,100	1,060	45,900
228	2,120	285	3,310	342	4,770	550	12,330	1,070	46,750
229	2,140	286	3,335	343	4,800	555	12,560	1,080	47,750
230	2,160	287	3,360	344	4,830	560	12,790	1,090	48,600
231	2,179	288	3,382	345	4,860	565	13,090	1,100	49,500
232	2,193	289	3,408	346	4,890	570	13,280	1,110	50,300
233	2,212	290	3,433	347	4,920	575	13,500	1,120	51,250
234	2,233	291	3,455	348	4,950	580	13,750	1,130	52,200
235	2,250	292	3,475	349	4,980	585	13,980	1,140	53,250
236	2,270	293	3,498	350	4,990	590	14,220	1,150	54,100
237	2,291	294	3,529	351	5,030	600	14,700	1,160	55,100
238	2,310	295	3,550	352	5,060	610	15,210	1,170	56,000
239	2,330	296	3,572	353	5,080	620	15,700	1,180	57,000
240	2,350	297	3,595	354	5,110	630	16,200	1,190	58,000
241	2,370	298	3,620	355	5,150	640	16,750	1,200	58,900
242	2,389	299	3,648						

(2) *Horizontal.*

- (a) When the capacity of a horizontal cylindrical tank is known, the quantity in the tank may be approximated by using the scale below.

Part of tank depth filled	Part of tank capacity filled
	1.000
0.95	.974
.90	.948
.85	.904
.80	.860
.75	.804
.70	.740
.65	.687
.60	.626
.55	.563
.50	.500
.45	.437
.40	.374
.35	.313
.30	.252
.25	.196
.20	.140
.15	.096
.10	.052
.05	.026

EXAMPLE: A horizontal tank is 80 inches in diameter. Depth of liquid in tank is 20 inches. Full tank capacity is 8,000 gallons. Find the number of gallons actually in tank.

$$\frac{20}{80} = 0.25 \text{ (part of tank depth filled)}$$

$$0.25 \text{ (part of tank depth filled)} = 0.196 \text{ (part of tank capacity filled)}$$

$$0.196 \times 8,000 = 1,568 \text{ gallons in tank}$$

- (b) When the capacity of a horizontal cylindrical tank is not known, the volume of liquid may be computed as shown below.

L = length of tank

l = depth of liquid in tank

r = radius of tank

h = distance from top of tank to surface of liquid

D = diameter of tank

a = cross-sectional length of "wet arc" formed by liquid, measured on lower part of tank

a' = cross-sectional length of "dry arc" above liquid, measured on upper part of tank

1. When tank is less than half full:

$$\text{Volume (gal.)} = \left[\frac{ar}{2} - (r - l) \sqrt{2rl - l^2} \right] \times \frac{L}{231}$$

2. When tank is half full:

$$\text{Volume (gal.)} = \frac{r^2 L}{147}$$

3. When tank is more than half full:

Volume (gal.)

$$= \left[3.1416r^2 - a'r + (r - h) \sqrt{2rh - h^2} \right] \times \frac{L}{231}$$

- (c) When it is not practical to measure a and a' in the formulas above (due to buried tanks, etc.), the lengths of these arcs can be computed by determining l/D and h/D ratios, and using the table below.

Tank less than half full				Tank more than half full			
l/D	Quantity to multiply D by to obtain a	l/D	Quantity to multiply D by to obtain a	h/D	Quantity to multiply D by to obtain a'	h/D	Quantity to multiply D by to obtain a'
.01	0.200	.26	1.070	.01	0.200	.26	1.070
.02	0.284	.27	1.093	.02	0.284	.27	1.093
.03	0.348	.28	1.115	.03	0.348	.28	1.115
.04	0.403	.29	1.137	.04	0.403	.29	1.137
.05	0.451	.30	1.159	.05	0.451	.30	1.159
.06	0.495	.31	1.181	.06	0.495	.31	1.181
.07	0.536	.32	1.203	.07	0.536	.32	1.203
.08	0.574	.33	1.224	.08	0.574	.33	1.224
.09	0.609	.34	1.245	.09	0.609	.34	1.245
.10	0.644	.35	1.266	.10	0.644	.35	1.266
.11	0.676	.36	1.287	.11	0.676	.36	1.287
.12	0.708	.37	1.308	.12	0.708	.37	1.308
.13	0.738	.38	1.328	.13	0.738	.38	1.328
.14	0.767	.39	1.349	.14	0.767	.39	1.349
.15	0.795	.40	1.369	.15	0.795	.40	1.369
.16	0.823	.41	1.390	.16	0.823	.41	1.390
.17	0.850	.42	1.410	.17	0.850	.42	1.410
.18	0.876	.43	1.430	.18	0.876	.43	1.430
.19	0.902	.44	1.451	.19	0.902	.44	1.451
.20	0.927	.45	1.471	.20	0.927	.45	1.471
.21	0.952	.46	1.491	.21	0.952	.46	1.491
.22	0.976	.47	1.511	.22	0.976	.47	1.511
.23	1.000	.48	1.531	.23	1.000	.48	1.531
.24	1.024	.49	1.551	.24	1.024	.49	1.551
.25	1.047	.50	1.571	.25	1.047	.50	1.571

- (d) The volume of liquid in flat-end horizontal cylindrical tanks of various sizes is given below. Quantities are in U.S. gallons for each liquid depth shown per foot of tank length. Therefore, in the formulas shown in (b) above, the ratio L/231 becomes a constant of 0.0519. To obtain liquid volume, multiply the figure from the table by the tank length (feet and fractions).

Depth of liquid in tank (in.)

	8	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
9	.95	2.34	3.30																	
12	1.15	2.95	4.73	5.9																
15	1.30	3.41	5.67	7.6	9.18															
18	1.45	3.85	6.61	9.4	11.8	13.2														
21	1.58	4.24	7.37	10.5	13.5	16.0	18.0													
24	1.70	4.61	8.10	11.8	15.5	18.9	21.8	23.5												
27	1.78	4.86	8.70	12.8	17.0	21.0	24.7	27.5	29.8											
30	1.91	5.23	9.30	13.7	18.4	23.0	27.5	31.5	34.8	36.8										
33	1.99	5.43	9.80	14.5	19.6	24.8	29.8	34.5	38.7	41.9	44.4									
36	2.12	5.80	10.3	15.4	20.9	26.4	32.0	37.5	42.5	47.1	50.8	52.9								
39	2.20	5.94	10.8	16.2	22.0	28.0	34.0	40.0	45.7	51.1	55.8	59.3	62.2							
42	2.28	6.31	11.3	17.0	23.1	29.5	36.0	42.5	48.9	55.0	60.7	65.7	69.7	72.0						
45	2.35	6.43	11.8	17.7	24.1	30.9	37.8	44.8	51.7	58.4	64.8	70.7	75.9	79.6	82.7					
48	2.45	6.78	12.2	18.4	25.1	32.2	39.5	47.0	54.5	61.8	68.9	75.6	81.8	87.2	91.6	94.0				
51	2.54	6.89	12.6	19.1	26.1	33.5	41.2	49.0	57.0	64.8	72.6	80.0	86.9	93.3	98.8	102.9	106.3			
54	2.61	7.23	13.0	19.7	27.0	34.7	42.8	51.1	59.5	67.9	76.2	84.3	92.0	99.3	105.9	111.8	116.4	119.0		
57	2.68	7.43	13.4	20.3	27.9	35.9	44.1	53.0	61.8	70.7	79.5	88.2	96.6	104.6	112.1	118.9	124.8	129.2	132.8	
60	2.76	7.64	13.8	20.9	28.7	37.1	45.8	54.9	64.1	73.5	82.8	92.0	101.1	109.8	118.2	126.0	133.1	139.3	144.1	146.9
63	2.82	7.84	14.2	21.5	29.5	38.2	47.3	56.7	66.3	76.0	85.9	95.5	105.2	114.6	123.7	132.3	140.2	147.5	153.7	158.3
66	2.89	8.05	14.6	22.1	30.4	39.3	48.7	58.4	68.4	78.6	88.9	99.1	109.3	119.3	129.1	138.5	147.4	155.7	163.2	169.7
69	2.95	8.23	14.9	22.5	31.2	40.2	50.0	60.1	70.5	81.0	91.7	102.6	113.2	123.7	134.1	144.2	153.8	163.0	171.4	179.1
72	3.02	8.42	15.3	23.2	31.9	41.4	51.3	61.7	72.5	83.4	94.5	105.8	117.0	128.1	139.1	149.8	160.2	170.2	179.6	188.4
75	3.08	8.60	15.6	23.5	32.7	42.4	52.6	63.3	74.4	85.7	97.2	108.9	120.5	132.2	143.7	155.1	166.1	176.8	187.0	196.7
78	3.15	8.78	15.9	24.2	33.4	43.3	53.9	64.9	76.3	88.0	99.9	112.0	124.1	136.3	148.3	160.3	172.0	183.4	194.4	204.9
81	3.20	8.95	16.2	24.7	34.2	44.3	55.1	66.5	78.1	90.2	102.4	115.0	127.5	140.2	152.7	165.2	177.5	189.5	201.2	212.4
84	3.25	9.12	16.6	25.2	34.9	45.2	56.3	67.9	79.9	92.3	105.0	117.9	130.9	144.0	157.0	170.0	182.9	195.6	208.0	220.0
87	3.34	9.29	16.9	25.7	35.6	46.2	57.5	69.4	81.7	94.3	107.4	120.7	134.1	147.6	161.2	174.7	188.0	201.3	214.4	227.0
90	3.43	9.45	17.2	26.2	36.2	47.1	58.6	70.8	83.4	96.4	109.8	123.5	137.3	151.2	165.3	179.3	193.2	207.0	220.7	234.1
93	3.47	9.61	17.5	26.7	36.9	48.0	59.7	72.2	85.1	98.4	111.6	126.1	140.3	154.7	169.2	183.7	198.1	212.5	226.7	240.6
96	3.50	9.78	17.8	27.1	37.5	48.8	60.8	73.5	86.7	100.4	114.4	128.8	143.4	158.2	173.1	188.0	203.0	217.9	232.6	247.2
99	3.56	9.89	18.1	27.6	38.3	49.7	61.9	74.8	88.3	102.3	116.7	131.4	146.4	161.5	176.8	192.2	207.7	223.0	238.3	253.5
102	3.61	10.1	18.4	28.0	39.0	50.5	63.0	76.2	89.9	104.2	118.9	133.9	149.3	164.8	180.5	196.4	212.3	228.1	244.0	259.7
105	3.66	10.3	18.6	28.5	39.5	51.3	64.0	77.5	91.5	106.1	121.1	136.4	152.1	168.0	184.1	200.4	216.7	233.1	249.4	265.6
108	3.71	10.4	18.9	28.9	40.0	52.1	65.1	78.7	93.0	107.9	123.2	138.9	154.9	171.2	187.7	204.4	221.1	238.0	254.8	271.5
111	3.77	10.6	19.2	29.4	40.6	52.9	66.1	79.9	94.5	109.6	125.2	141.3	157.6	174.3	191.2	208.2	225.4	242.9	259.9	277.0
114	3.82	10.7	19.5	29.8	41.1	53.7	67.1	81.2	96.0	111.4	127.3	143.7	160.4	177.4	194.7	212.1	229.7	247.8	265.0	283.3
117	3.87	10.9	19.7	30.2	41.6	54.0	67.9	82.4	97.6	113.2	129.5	145.8	162.9	180.3	198.8	215.8	233.8	252.3	270.0	288.5
120	3.92	11.0	19.8	30.6	42.0	54.2	68.7	83.6	99.2	114.9	131.8	148.0	165.5	183.2	203.0	219.5	238.0	256.8	274.9	294.0

Depth of liquid in tank (in.)

	63	66	69	72	75	78	81	84	87	90	93	96	99	102	105	108	111	114	117	120
9																				
12																				
15																				
18																				
21																				
24																				
27																				
30																				
33																				
36																				
39																				
42																				
45																				
48																				
51																				

	63	66	69	72	75	78	81	84	87	90	93	96	99	102	105	108	111	114	117	120
Tank diameter (in.)																				
54																				
57																				
60																				
63	162.2																			
66	174.8	177.7																		
69	185.6	190.4	194.6																	
72	196.3	203.1	208.5	211.5																
75	205.6	213.6	220.4	225.5	230.0															
78	214.8	224.0	232.3	239.5	245.1	248.2														
81	223.2	233.4	242.7	251.1	258.2	263.5	268.0													
84	231.6	242.7	253.1	262.7	271.3	278.8	284.6	287.9												
87	239.4	251.2	262.5	273.1	282.8	291.6	299.0	303.9	308.7											
90	247.1	259.7	271.9	283.4	294.3	304.3	313.3	321.0	327.1	330.5										
93	254.4	267.7	280.6	292.9	304.8	315.8	327.9	335.0	342.6	343.4	352.9									
96	261.6	275.6	289.3	302.5	315.2	327.2	338.5	348.9	358.2	366.2	372.5	376.0								
99	268.4	283.1	297.5	311.4	324.8	337.8	350.0	361.4	371.9	381.4	389.3	395.2	399.5							
102	275.2	290.6	305.6	320.3	334.5	348.3	361.5	374.0	385.5	396.5	406.1	414.4	420.1	424.5						
105	281.7	297.6	313.3	328.7	343.6	358.2	372.2	385.6	398.2	410.1	421.0	430.7	437.1	445.0	449.5					
108	288.2	304.7	321.0	337.0	352.7	368.0	382.9	397.2	410.8	423.7	435.9	447.0	454.0	465.5	470.0	475.9				
111	294.4	311.5	328.4	345.0	361.3	377.4	392.9	407.6	422.4	436.4	449.0	461.5	471.0	482.8	490.5	497.4	502.6			
114	300.6	318.3	335.8	353.0	369.9	386.7	402.9	418.0	434.0	449.0	462.0	476.0	488.0	500.0	511.0	519.0	526.0	531.0		
117	306.3	324.2	342.4	360.0	377.9	394.9	411.9	428.3	444.0	460.5	474.8	489.8	503.0	516.0	527.0	537.5	546.5	553.6	558.0	
120	312.0	330.0	349.0	367.0	386.0	403.0	421.0	438.5	454.0	472.0	487.5	503.5	518.0	532.0	543.0	556.0	567.0	576.2	580.0	588.0

c. *Rectangular Tanks.* The table below gives liquid volumes for each foot of liquid depth in rectangular tanks of various sizes. To obtain total liquid volume, multiply the figure shown by liquid depth (feet and fractions). Figures in the table were obtained from the following formula:

$$\text{Volume (gal.)} = \frac{Lwl}{231}$$

Where

L = length of tank in inches
w = width of tank in inches
l = depth of liquid in inches

Length of tank (in.)

	12	15	18	21	24	27	30	33	36
Width of tank (in.)									
12	7.48	9.35	11.23	13.10	14.95	16.85	18.70	20.58	22.46
15	9.36	11.68	14.02	16.36	18.72	21.00	23.33	25.70	28.02
18	11.23	14.02	16.83	19.65	22.44	25.25	28.05	30.90	33.66
21	13.10	16.36	19.65	22.90	26.18	29.50	32.70	36.00	39.30
24	14.95	18.72	22.44	26.18	29.97	33.70	37.40	41.20	44.80
27	16.85	21.00	25.25	29.50	33.70	37.90	42.10	46.30	50.50
30	18.70	23.33	28.05	32.70	37.40	42.10	46.80	51.50	56.10
33	20.58	25.70	30.90	36.00	41.20	46.30	51.50	56.60	61.80
36	22.46	28.02	33.66	39.30	44.80	50.50	56.10	61.80	67.30
39	24.30	30.40	36.50	42.60	48.70	54.70	60.80	66.90	72.90
42	26.19	32.70	39.24	45.80	52.30	58.90	65.50	72.00	78.50
45	28.05	35.10	42.10	49.10	56.10	63.10	70.20	77.20	84.20
48	29.93	37.40	44.90	52.30	59.80	67.30	74.80	82.30	89.80
51	31.75	39.71	47.70	55.70	63.60	71.50	79.60	87.50	95.40
54	33.70	42.10	50.50	58.80	67.30	75.70	84.10	92.60	101.00
57	35.50	44.40	53.25	62.20	71.00	80.00	88.80	97.70	106.60
60	37.40	46.75	56.10	65.40	74.80	84.10	93.50	102.90	112.20
63	39.30	49.10	58.90	68.70	78.40	88.40	98.20	108.00	117.70
66	41.10	51.40	61.70	72.00	82.30	92.50	102.80	113.30	123.40
69	43.10	53.70	64.50	75.20	85.90	96.80	107.40	118.40	129.00
72	44.90	56.10	67.30	78.50	89.70	100.90	112.20	123.50	134.60
75	46.75	58.40	70.10	81.80	93.40	105.10	117.00	128.60	140.10
78	48.60	60.75	72.90	85.10	97.20	109.30	121.60	133.70	145.90

Length of tank (in.)

	12	15	18	21	24	27	30	33	36
Width of tank (in.)									
81	50.50	63.10	75.70	88.30	100.80	113.50	126.30	139.00	151.40
84	52.40	65.50	78.60	91.60	104.60	117.60	131.00	144.00	157.10
87	54.20	67.80	81.30	94.80	108.30	122.00	135.60	149.20	162.60
90	56.10	70.20	84.20	98.20	112.20	126.10	140.30	154.50	168.30
93	58.00	72.45	86.90	101.40	115.70	130.40	145.00	159.50	174.00
96	59.80	74.80	89.80	104.50	119.60	134.50	149.60	164.50	179.50
99	61.70	77.20	92.60	108.00	123.50	138.90	154.40	169.70	185.20
102	63.60	79.60	95.50	111.20	127.20	143.00	158.90	174.50	190.70
105	65.40	81.90	98.30	114.50	131.00	147.30	163.60	179.60	196.40
108	67.30	84.20	101.20	117.80	134.60	151.50	168.30	184.90	202.00
111	69.20	86.60	103.90	121.00	138.30	155.50	173.00	190.00	205.20
114	71.00	88.90	106.70	124.40	142.10	159.80	177.70	195.00	213.20
117	72.80	91.30	109.50	127.50	145.90	164.00	182.40	200.50	219.00
120	74.75	93.60	112.40	130.80	149.60	168.20	187.00	205.30	224.40

Length of tank (in.)

	39	42	45	48	51	54	57	60	63
Width of tank (in.)									
12	24.30	26.19	28.05	29.93	31.75	33.70	35.50	37.40	39.30
15	30.40	32.70	35.10	37.40	39.71	42.10	44.40	46.75	49.10
18	36.50	39.24	42.10	44.90	47.70	50.50	53.25	56.10	58.90
21	42.60	45.80	49.10	52.30	55.70	58.80	62.20	65.40	68.70
24	48.70	52.30	56.10	59.80	63.60	67.30	71.00	74.80	78.40
27	54.70	58.90	63.10	67.30	71.50	75.70	80.00	84.10	88.40
30	60.80	65.50	70.20	74.80	79.60	84.10	88.80	93.50	98.20
33	66.90	72.00	77.20	82.30	87.50	92.60	97.70	102.90	108.00
36	72.90	78.50	84.20	89.80	93.40	101.00	106.60	112.20	117.70
39	79.00	85.10	91.10	97.20	103.30	109.40	115.50	121.60	127.60
42	85.10	91.60	98.10	104.70	111.20	117.80	124.40	131.00	137.40
45	91.10	98.10	105.20	112.20	119.20	126.20	133.20	140.20	147.20
48	97.20	104.70	112.20	119.70	127.20	134.60	142.00	149.50	157.00
51	103.30	111.20	119.20	127.20	135.00	143.00	151.00	158.90	166.80
54	109.40	117.80	126.20	134.60	143.00	151.50	159.90	168.30	176.60
57	115.50	124.40	133.20	142.00	151.00	159.90	168.80	177.50	186.50
60	121.60	131.00	140.20	149.50	158.90	168.30	177.50	187.00	196.40
63	127.60	137.40	147.20	157.00	166.80	176.60	186.50	196.40	206.00
66	133.90	144.00	154.10	164.60	174.60	185.10	195.50	205.50	215.80
69	139.80	150.50	161.20	172.00	182.60	193.50	204.50	215.00	225.30
72	146.00	157.10	168.10	179.50	190.50	202.00	213.00	224.30	235.20
75	152.00	163.50	175.20	187.00	198.50	210.30	222.00	233.30	245.00
78	158.00	170.20	182.20	194.50	206.40	219.00	231.00	243.00	255.00
81	164.10	176.60	189.30	202.00	214.50	227.00	239.90	252.30	264.90
84	170.20	183.30	196.30	209.40	222.50	235.60	249.00	261.60	274.90
87	176.40	289.80	203.30	217.00	230.50	244.00	257.80	271.00	284.60
90	182.50	196.40	210.30	224.40	238.50	252.50	266.90	280.50	294.10
93	188.50	203.00	217.20	231.90	246.10	261.00	275.20	289.80	304.00
96	194.40	209.50	224.40	239.40	254.10	269.30	284.00	299.30	314.00
99	200.50	216.00	231.50	247.00	262.10	277.80	293.00	308.80	324.00
102	206.50	222.50	238.50	254.30	270.00	286.00	302.00	318.00	333.20
105	212.50	229.00	245.30	261.50	278.00	294.50	311.00	327.20	343.20
108	218.60	235.60	252.70	269.30	286.00	303.00	319.80	336.60	353.00
111	224.80	242.00	259.80	276.60	294.00	311.00	328.80	346.00	362.90
114	230.90	248.70	266.90	284.20	302.00	319.80	337.80	355.30	372.90
117	237.00	255.00	273.90	291.50	310.00	328.20	346.50	365.00	382.90
120	242.90	261.80	280.70	299.10	318.00	336.60	355.30	374.00	392.20

		Length of tank (in.)								
		66	69	72	75	78	81	84	87	90
Width of tank (in.)	12	41.10	43.10	44.90	46.75	48.60	50.50	52.40	54.20	56.10
	15	51.40	53.75	56.10	58.40	60.75	63.10	65.50	67.80	70.20
	18	61.70	64.50	67.30	70.10	72.90	75.70	78.60	81.30	84.20
	21	72.00	75.20	78.50	81.80	85.10	88.30	91.60	94.80	98.20
	24	82.30	85.90	89.70	93.40	97.20	100.80	104.60	108.30	112.20
	27	92.50	96.80	100.90	105.10	109.30	113.50	117.60	122.00	126.10
	30	102.80	107.40	112.20	117.00	121.60	126.30	131.00	135.60	140.30
	33	113.30	118.40	123.50	128.60	133.70	139.00	144.00	149.20	154.50
	36	123.40	129.00	134.60	140.10	145.90	151.40	157.10	162.60	168.30
	39	133.90	139.80	146.00	152.00	158.00	164.10	170.20	176.40	182.50
	42	144.00	150.50	157.10	163.50	170.20	176.60	183.30	189.80	196.40
	45	154.10	161.20	168.10	175.20	182.20	189.30	196.30	203.30	210.30
	48	164.60	172.00	179.50	187.00	194.50	202.00	209.40	217.00	224.40
	51	174.60	182.60	190.50	198.50	206.40	214.50	222.50	230.50	238.50
	54	185.10	193.50	202.00	210.30	219.00	227.00	235.60	244.00	252.50
	57	195.50	204.50	213.00	222.00	231.00	239.90	249.00	257.80	266.90
	60	205.50	215.00	224.30	233.30	243.00	252.30	261.60	271.00	280.50
	63	215.80	225.30	235.20	245.00	255.00	264.90	274.90	284.60	294.10
	66	226.30	236.80	247.00	257.00	267.40	277.90	288.00	298.00	308.60
	69	236.80	247.40	258.00	269.00	279.80	290.40	301.50	312.00	322.80
	72	247.00	258.00	269.30	280.40	291.60	302.90	314.20	325.00	336.50
	75	257.00	269.00	280.40	292.20	303.90	315.80	327.00	339.00	350.40
	78	267.40	279.80	291.60	303.90	316.00	328.00	340.30	352.80	364.70
	81	277.90	290.40	302.90	315.80	328.00	341.00	353.50	366.00	379.00
84	288.00	301.50	314.20	327.00	340.30	353.50	366.50	379.90	393.00	
87	298.00	312.00	325.00	339.00	352.80	366.00	379.90	393.00	406.80	
90	308.60	322.80	336.50	350.40	364.70	379.00	393.00	406.80	421.00	
93	319.00	333.00	347.50	362.00	377.00	391.50	406.00	421.00	435.00	
96	329.00	342.10	359.00	373.90	389.00	403.50	419.00	433.50	449.00	
99	339.30	355.00	370.70	385.80	401.00	416.00	432.00	447.00	462.50	
102	349.60	365.80	381.40	397.00	413.20	428.50	445.00	460.70	477.00	
105	360.00	376.80	392.90	408.00	425.50	442.00	458.00	474.50	491.00	
108	370.30	387.20	404.00	421.00	437.80	454.00	471.10	487.00	505.00	
111	380.60	398.00	415.00	432.00	449.00	467.00	484.00	501.50	519.00	
114	391.00	408.00	426.40	444.00	462.00	479.00	497.50	515.00	533.00	
117	401.70	419.00	437.50	456.00	474.00	492.00	510.90	528.00	547.50	
120	411.50	430.70	449.00	467.00	486.00	504.90	523.00	542.00	561.00	

		Length of tank (in.)								
		93	96	99	102	105	108	111	114	117
Width of tank (in.)	12	58.00	59.80	61.70	63.60	65.40	67.30	69.20	71.00	72.80
	15	72.45	74.80	77.20	79.60	81.90	84.20	86.60	88.90	91.30
	18	86.90	89.80	92.60	95.50	98.30	101.20	103.90	106.70	109.50
	21	101.40	104.50	108.00	111.20	114.50	117.80	121.00	124.40	127.50
	24	115.70	119.60	123.50	127.20	131.00	134.60	138.30	142.10	145.90
	27	130.40	134.50	138.90	143.00	147.30	151.50	155.50	159.80	164.00
	30	145.00	149.60	154.40	158.90	163.60	168.30	173.00	177.70	182.40
	33	159.50	164.50	169.70	174.50	179.60	184.90	190.00	195.00	200.50
	36	174.00	179.50	185.20	190.70	196.40	202.00	205.20	213.20	219.00
	39	188.50	194.40	200.50	206.50	212.50	218.60	224.80	230.90	237.00
	42	203.00	209.50	216.00	222.50	229.00	235.60	242.00	248.70	255.00
	45	217.20	224.40	231.50	238.50	245.30	252.70	259.80	266.90	273.90
	48	231.90	239.40	247.00	254.30	261.50	269.30	276.60	284.20	291.50
	51	246.10	254.10	262.10	270.00	278.00	286.00	294.00	302.00	310.00
	54	261.00	269.30	277.80	286.00	294.50	303.00	311.00	319.80	328.20
	57	275.20	284.00	293.00	302.00	311.00	319.80	328.80	337.80	346.50
60	289.80	299.30	308.80	318.00	327.20	336.60	346.00	355.30	365.00	
63	304.00	314.00	324.00	333.20	343.20	353.00	362.90	372.90	382.90	
66	319.00	329.00	339.30	349.60	360.00	370.30	380.60	391.00	401.70	

		Length of tank (in.)								
		93	96	99	102	105	108	111	114	117
Width of tank (in.)	69	333.00	342.10	355.00	365.80	376.80	387.20	398.00	408.00	419.00
	72	347.50	359.00	370.70	381.40	392.90	404.00	415.00	426.40	437.50
	75	362.00	373.90	385.80	397.00	408.00	421.00	432.00	444.00	456.00
	78	377.00	389.30	401.00	413.20	425.50	437.80	449.00	462.00	474.00
	81	391.50	403.50	416.00	428.50	442.00	454.00	467.00	479.00	492.00
	84	406.00	419.00	432.00	445.00	458.00	471.10	484.00	497.50	510.90
	87	421.00	433.50	447.00	460.70	474.50	487.00	501.50	515.00	528.00
	90	435.00	449.00	462.50	477.00	491.00	505.00	519.00	533.00	547.50
	93	449.00	463.00	478.00	492.00	507.00	521.00	536.00	550.00	564.90
	96	463.00	478.80	494.00	508.70	524.00	539.00	554.00	568.50	584.00
	99	478.00	493.50	509.80	525.00	540.00	556.00	571.00	587.00	602.00
	102	492.00	508.70	525.00	540.90	557.00	572.00	587.50	604.00	620.00
	105	507.00	524.00	540.00	557.00	572.50	589.00	605.00	622.00	638.00
	108	521.00	539.00	556.00	572.00	589.00	606.00	622.50	639.90	657.00
	111	536.00	554.00	571.00	587.50	605.00	622.50	639.00	657.00	674.00
114	550.00	568.50	587.00	604.00	622.00	639.90	657.00	675.80	693.00	
117	564.90	584.00	602.00	620.00	638.00	657.00	674.00	693.00	712.00	
120	579.00	598.00	617.00	636.00	654.00	673.00	691.00	711.00	729.90	

		Length of tank (in.)						
		120	123	126	129	132	135	138
Width of tank (in.)	12	74.75	76.70	78.50	80.40	82.25	84.10	86.00
	15	93.60	95.90	98.30	100.50	103.00	105.30	107.60
	18	112.40	115.20	118.00	120.80	123.50	126.50	129.20
	21	130.80	134.10	137.40	140.50	143.90	147.20	150.50
	24	149.60	153.50	157.10	160.90	164.50	168.30	172.00
	27	168.20	172.50	176.70	180.90	185.00	189.40	193.50
	30	187.00	191.80	196.40	201.30	205.70	210.50	215.10
	33	205.30	210.50	215.50	220.90	226.00	231.00	236.00
	36	224.40	230.00	235.60	241.00	246.90	252.50	258.10
	39	242.90	249.00	255.00	261.00	267.00	273.30	279.70
	42	261.80	268.50	274.90	281.00	288.00	294.40	301.10
	45	280.70	287.50	294.50	302.00	308.00	315.50	322.80
	48	299.10	304.80	314.10	321.80	329.00	336.80	344.00
	51	318.00	325.90	333.80	341.80	349.80	357.80	365.80
	54	336.60	345.00	353.40	362.00	370.30	378.80	387.00
	57	355.30	364.30	373.00	382.00	391.00	400.00	409.00
	60	374.00	383.80	392.80	402.50	411.40	421.00	430.30
	63	392.20	402.00	412.00	422.00	432.00	441.80	451.80
	66	411.50	421.50	432.00	442.00	452.50	463.00	473.00
	69	430.70	441.00	452.00	462.50	473.00	484.00	495.00
	72	449.00	460.00	471.30	482.00	493.50	505.00	516.00
	75	467.00	479.00	491.00	502.00	514.00	526.00	537.50
	78	486.00	498.00	510.50	522.50	535.00	547.00	559.00
	81	504.90	517.00	530.00	542.50	555.00	567.50	580.50
84	523.00	537.00	549.80	562.50	576.00	589.00	602.00	
87	542.00	556.00	569.50	582.50	597.00	610.00	623.00	
90	561.00	575.00	589.00	603.00	617.00	631.00	645.00	
93	579.00	593.00	607.50	622.50	637.00	652.00	666.00	
96	598.00	614.00	628.00	644.00	658.30	674.00	688.00	
99	617.00	632.50	648.00	663.00	679.00	694.90	711.00	
102	636.00	652.00	667.50	684.00	699.00	715.80	732.00	
105	654.00	671.00	687.50	703.00	719.50	736.50	752.50	
108	673.00	690.00	707.50	723.50	741.00	757.50	774.00	
111	691.00	709.00	726.00	743.00	760.00	777.50	795.00	
114	711.00	729.00	747.00	764.00	782.00	800.00	818.00	
117	729.90	748.00	766.00	784.00	802.50	820.00	839.00	
120	747.50	767.00	785.00	804.00	823.00	842.00	860.00	

d. Elliptical Tanks (Horizontal).

- (1) *Formula.* The full capacity in gallons of horizontal elliptical tanks with flat ends can be computed by the following formula.

$$\text{Volume (gal.)} = \frac{.7854abL}{231}$$

where

a = long axis of elliptical cross-section
b = short axis of elliptical cross-section
L = length of tank

- (2) *Table.* For tanks of known capacity, the partial content in gallons for varying liquid depths can be determined by using the scale below. (See *b(2)* above for example of use.)

Part of tank depth filled	Part of tank capacity filled	Part of tank depth filled	Part of tank capacity filled	Part of tank depth filled	Part of tank capacity filled
0.01	0.0020	0.35	0.3119	0.68	0.7234
0.02	0.0050	0.36	0.3244	0.69	0.7352
0.03	0.0090	0.37	0.3366	0.70	0.7469
0.04	0.0134	0.38	0.3490	0.71	0.7593
0.05	0.0187	0.39	0.3614	0.72	0.7700
0.06	0.0245	0.40	0.3739	0.73	0.7814
0.07	0.0307	0.41	0.3864	0.74	0.7927
0.08	0.0374	0.42	0.3989	0.75	0.8039
0.09	0.0445	0.43	0.4114	0.76	0.8150
0.10	0.0520	0.44	0.4240	0.77	0.8260
0.11	0.0598	0.45	0.4366	0.78	0.8368
0.12	0.0680	0.46	0.4492	0.79	0.8474
0.13	0.0764	0.47	0.4619	0.80	0.8577
0.14	0.0850	0.48	0.4745	0.81	0.8677
0.15	0.0940	0.49	0.4873	0.82	0.8776
0.16	0.1032	0.50	0.5000	0.83	0.8873
0.17	0.1127	0.51	0.5127	0.84	0.8968
0.18	0.1224	0.52	0.5255	0.85	0.9060
0.19	0.1323	0.53	0.5381	0.86	0.9150
0.20	0.1423	0.54	0.5508	0.87	0.9236
0.21	0.1526	0.55	0.5634	0.88	0.9320
0.22	0.1632	0.56	0.5760	0.89	0.9402
0.23	0.1740	0.57	0.5886	0.90	0.9480
0.24	0.1850	0.58	0.6011	0.91	0.9555
0.25	0.1961	0.59	0.6136	0.92	0.9626
0.26	0.2073	0.60	0.6261	0.93	0.9693
0.27	0.2186	0.61	0.6386	0.94	0.9755
0.28	0.2300	0.62	0.6510	0.95	0.9813
0.29	0.2407	0.63	0.6634	0.96	0.9866
0.30	0.2531	0.64	0.6756	0.97	0.9910
0.31	0.2648	0.65	0.6881	0.98	0.9950
0.32	0.2766	0.66	0.6997	0.99	0.9980
0.33	0.2884	0.67	0.7116	1.00	1.0000
0.34	0.3003				

e. Spherical Tanks. The table ((4) below) may be used to determine the liquid volume in spherical tanks for various depths of the liquid. Also shown

are three formulas which may be used instead of the table. When more precise computations are desired, use the formulas which do not require figures from the table. Volumes are shown in cubic inches; cubic inches are divided by 231 to obtain gallons. In this subparagraph, the words "sphere" and "tank" have the same meaning, and the letters used represent the following:

d = depth of liquid or height of segment of sphere formed by liquid (when tank is less than half full)

= distance from top of sphere to surface of liquid (when tank is more than half full)

C = a value for different d/D relationships which represents the volume of the sphere segment divided by the cube of the sphere's diameter

D = diameter of tank

- (1) *When tank is less than half full:*

(a) To find the volume of the liquid, form the ratio d/D and find the value of C in the table. Then Volume of liquid = D^3C

(b) Alternate method: (table not required)
Volume of liquid = $.5236d^2(3D - 2d)$

- (2) *When tank is half full:*

Volume of liquid = $.2618D^3$ (table not required)

- (3) *When tank is more than half full:*

(a) Since the ratio d/D (if d is considered the depth of liquid) becomes greater than 0.50, the table no longer applies. Therefore, the table should be used to determine the volume of the unfilled portion. Subtract this from the total volume of the tank ($.5236D^3$) to obtain the volume of the filled portion. In this case, d becomes the distance from the top of tank to the surface of liquid. To find the volume of the unfilled portion, form the ratio d/D and find the value of C in the table. The unfilled portion is then D^3C , and the volume of the filled portion can be determined as follows:

$$\begin{aligned}\text{Volume of liquid} &= .5236D^3 - D^3C \\ &= D^3(.5236 - C)\end{aligned}$$

(b) Alternate method: (table not required)

$$\begin{aligned}\text{Volume of liquid} &= .5236D^3 \\ &- [.5236d^2(3D - 2d)]\end{aligned}$$

- (4) *Table.*

d/D	C	d/D	C	d/D	C	d/D	C	d/D	C
0.01	0.0002	0.11	0.0176	0.21	0.0596	0.31	0.1198	0.41	0.1919
0.02	0.0006	0.12	0.0208	0.22	0.0649	0.32	0.1265	0.42	0.1995
0.03	0.0014	0.13	0.0242	0.23	0.0704	0.33	0.1334	0.43	0.2072
0.04	0.0024	0.14	0.0279	0.24	0.0760	0.34	0.1404	0.44	0.2149
0.05	0.0038	0.15	0.0318	0.25	0.0818	0.35	0.1475	0.45	0.2227
0.06	0.0054	0.16	0.0359	0.26	0.0878	0.36	0.1547	0.46	0.2305
0.07	0.0073	0.17	0.0403	0.27	0.0939	0.37	0.1620	0.47	0.2383
0.08	0.0095	0.18	0.0448	0.28	0.1002	0.38	0.1694	0.48	0.2461
0.09	0.0120	0.19	0.0495	0.29	0.1066	0.39	0.1768	0.49	0.2539
0.10	0.0147	0.20	0.0545	0.30	0.1131	0.40	0.1843	0.50	0.2618

f. Temperature Corrections (Approximate) for POL Products.

Product	Coefficient of expansion or contraction (base of 60° F.)*
Aviation gasoline.....	0.00070
Motor gasoline and naptha (other than cleaning solvent).....	0.00060
Light crude oil (above 35° API gravity), jet fuel, cleaning solvent, kerosene, distillate fuel oil, and fog oil.....	0.00050
Medium crude oil (15° to 35° API gravity), and lubricating oil.....	0.00040
Heavy crude oil (up to 15° API gravity), residual oil, and asphalt.....	0.00035

* Refers to change in unit volume per degree over or under 60° F.

7.29 Dimensions of Containers

Nomenclature	Units in package	Type of package	Size of package (in.)		
			Length	Width or diameter	Height
Drum:					
U.S. 55-gal., 16-gage.	1	Drum	0	24 1/8	34 3/4
U.S. 55-gal., 18-gage.	1	Drum	0	24 5/8	34 7/8
Can:					
U.S. 5-gal. (gasoline).	1	Can	13 3/4	6 1/2	18 3/8
U.S. 5-gal. (oil)---	2	Case	0	11 15/16	14 3/16
U.S. 5-qt. (oil)---	6	Case	0	14	10
U.S. 1-qt. (oil)---	12	Case	18	13	6
Pail:					
U.S. 25-lb (grease).	1	Pail	0	11 1/2	11 1/2

7.30. Bulk Capacities

Carrier	Gallons	Short tons	
		Gasoline 91A (bulk)	Lube oil (bulk)
Barge, coastwise ¹	200,000 to 400,000	614 to 1,228	761 to 1,522
Barge, harbor and canal ²	15,000 to 30,000	45.9 to 91.8	57 to 114
Barge, Navy ponton ³	84,000	257	320
Pipeline:⁴			
4-inch.....	304,000 per day	930	1,150
6-inch.....	655,000 per day ⁵	2,000	2,500
8-inch.....	1,135,000 per day	3,500	4,350
Railroad tank car.....	8,000; 10,000; 12,000	24.1; 30.6; 36.8	30.4; 38.1; 45.7
Semitrailer, 12-ton 4W.....	5,000	15.3	19
Ship, large tanker ⁶	2.5 to 11 million	7,620 to 33,500	9,480 to 43,800
Ship, small tanker ⁷	600,000 to 2 million	1,830 to 6,140	2,280 to 7,610
Tank, bolted-steel.....	10,500; 42,000; 420,000	32.2; 128; 1,280	39.9; 160; 1,600
Tank, portable fabric ⁸	10,000	30.6	38.1
Tank truck, F-3, fuel or oil.....	750	2.3	2.9
Tank truck, L-2, oil service.....	600	1.8	2.3
Trailer, fuel servicing.....	600	1.8	2.3
Transporter, liquid, rolling-wheel type (RLT), 1,000 gal. T3 ⁹	1,000	3.0	3.7

See footnotes on page 324.

Carrier	Gallons	Short tons	
		Gasoline 91A (bulk)	Lube oil (bulk)
Truck tractor and trailer, F-1.....	4,000	12.2	15.2
Truck tractor and 2 trailers, F-1A.....	8,000	24.4	30.4
Truck tractor and trailer, F-2.....	2,000	6.1	7.6
Truck tractor and 2 trailers, F-2A.....	4,000	12.2	15.2

¹ Molded hulls.

² Rectangular hulls.

³ 6 × 18 ponton barge carrying three 42,000-gallon tanks loaded to two-thirds capacity.

⁴ In maintaining the same volumetric pipeline capacity for gasoline and oil, more pressure is required for the heavier liquid.

⁵ Based on 32,500 gallons per hour for 20 hours of operation. In an emergency it can deliver 30,000 gallons per hour for 24 hours of operation, or 720,000 gallons per day.

⁶ The ship tanker most commonly used is the T2-SE-A1, a 5,922,000-gallon tanker. It is 425 feet long and draws 31 feet. Has three 8-flanged discharge outlets and four discharge pumps rated 1,000 gpm at 100 psi.

⁷ Draft loaded, 12 to 20 feet.

⁸ 40 feet long, 12 feet wide, 3 feet high when filled. When empty, it can be rolled to 20 inches by 12 feet; 10 can be carried in a 6 × 6 truck.

⁹ A pair of removable synthetic-rubber containers (fuel cells) mounted on an axle and towing unit. Each cell has a capacity of 500 gal.

Section VIII. SUPPLY

7.31 Classes of Supply

Class	Definition	How obtained
I	Articles consumed at an approximately uniform rate, such as rations.	From QM class I distributing points. Basis of issue is the daily report of personnel strength and equipment status submitted through channels.
II	Articles authorized by established allowances, such as TOE's, TA's, or special authorizations.	By requisition. Often submitted through channels to Army or section special staff officer of the supplying technical service.
III	Fuels, lubricants, fuel oils, coal..... and	Directly from Army or logistical command distribution points.
III(A)	Aviation fuels and lubricants.....	Obtained on credit basis or by exchange of empty for filled containers.
IV	Supplies and equipment in excess of, or not authorized by, established allowances, not in any other class, or transferred to class IV because special control measures are required.	By requisition. Submitted as for class III items. Depots normally require staff approval before issue. Critical items require authority of superior headquarters.
IV(A)	Aircraft, and aircraft equipment, parts, and supplies..	From Transportation Army aircraft maintenance and supply units.
V	Ammunition, pyrotechnics, land, mines, and chemicals.	Normally by credit allocations to troop units, authorizing ammunition supply points.

7.32 Shipping Data on Commonly Transported Items

a. Rations.

Type	Package or case			Ration or packet including packaging		Avg calories per ration
	Contents	Weight (lb)	Cu ft	Avg weight (lb)	Avg vol (cu ft)	
Field A ¹				6.0	0.183	4,200
Operational B ²				6.0	0.127	4,400
Small detachment, 5 persons ³	5 rations	28.5	1.1	5.8	0.2	3,600
Combat, indiv ⁴	6 rations	38	1.2	6.5	0.2	3,600
Trail, frigid, indiv ⁵	8 rations	34	1.6	4.0	0.2	4,400
Supplement, sundries pack (1 pack per 100 men) ⁶		47	1.9			

Type	Package or case			Ration or packet including packaging		Avg calories per ration
	Contents	Weight (lb)	Cu ft	Avg weight (lb)	Avg vol (cu ft)	
Indiv, combat, meal type	4 rations	24	-----	4.8	0.85	3,600
Supplement, aid station (205 8-oz drinks) ⁷	-----	20	1.1	-----	-----	-----
Food packet, assault, indiv ⁸	24 packets	29	1.1	1.1	-----	800
Survival:	-----	-----	-----	-----	-----	-----
Arctic, SA ⁹	24 packets	34	0.7	1.5	-----	2,000
Tropic, ST ¹⁰	24 packets	36	0.7	1.5	-----	1,700

¹ Basic field ration of approximately 200 items, including such perishables as fresh and frozen meats, vegetables, and fruit. For use primarily under stable conditions and during static phases of military operations when there are normal cooking and refrigeration facilities. Should be issued in preference to any other type of ration whenever circumstances permit its use. Components, weight, and volume vary.

² Canned or dry items and staple items; for use whenever mess facilities and personnel are available and no perishable foods are issued. Components, weight, and volume vary. SB 10-495 has information on its breakdown. Ration supplement, spice pack, consist of assorted spices, condiments, and leavening agents to supplement 1,000 operational rations B. The spice pack varies in weight and volume, being tailor-made for different situations and scaled to the B ration.

³ Nonperishable precooked food which may be eaten hot when organized messing is impossible but feeding in small groups is possible.

⁴ Nonperishable precooked food which may be eaten hot or cold, carried and prepared by the individual soldier. For use when the tactical situation is so unstable that messing in small groups is not possible and kitchen facilities are not available.

⁵ For use in extremely cold climates by small patrols or trail teams when resupply is impossible.

⁶ Comfort items such as toilet articles, tobacco and candy as a supplement to ration B, for issue before the establishment of adequate sales facilities.

⁷ Special nourishment in the form of hot stimulating beverages for combat zone casualties at aid and clearing stations.

⁸ Lightweight, highly palatable food conveniently carried by the individual in the initial assault phase of combat. Not for use for longer periods than 80 hours.

⁹ For survival kits aboard aircraft operating over arctic regions, in the emergency kit forming a part of the ejection seat in combat aircraft, and in emergency kits for passengers aboard transport aircraft.

¹⁰ Palatable food of high caloric density carried in survival kits of aircraft operating over the tropics.

b. Ammunition.

Nomenclature	Number per unit	Weight (lb)		Cubic feet		Stowage factor	
		Crated	Uncrated	Crated	Uncrated	Crated	Uncrated
Canister, N2, 37mm, G	20	102	-----	2.04	-----	45	-----
Cart, AP, cal .30, in cartons	1,500	112	-----	1.5	-----	30	-----
Cart, AP, cal .30, 8 rd clip	1,440	112	-----	1.5	-----	30	-----
Cart, AP, cal .50, in cartons	300	97	-----	1.5	-----	35	-----
Cart, AP, cal .50, in cartons	350	112	-----	1.5	-----	30	-----
Cart, AP, 7.62mm, in cartons, grade R	960	72	-----	.91	-----	28	-----
Cart, AP, 7.62mm, in cartons, grade R	1,040	78	-----	1.28	-----	37	-----
Cart, AP, 7.62mm, in cartons, grade R	1,200	86	-----	1.28	-----	33	-----
Cart, AP, 7.62mm, in cartons, grade MG	1,200	86	-----	1.28	-----	33	-----
Cart, AP, I&T, cal .30 1/b	1,200	101	-----	1.5	-----	33	-----
Cart, AP, I&T, cal .50, 1/b	265	103	-----	1.5	-----	33	-----
Cart, AP&T, cal .30, w/b (100 rds)	1,200	92	-----	1.5	-----	37	-----
Cart, AP&T, cal .30, w/b	1,240	98	-----	1.5	-----	34	-----
Cart, AP&T, cal .30, w/b	1,250	100	-----	1.5	-----	34	-----
Cart, AP&T, cal .30, 1/b	1,200	107	-----	1.5	-----	31	-----
Cart, AP&T, w/b, 250 rd mg, chest	1,000	77	-----	.9	-----	26	-----
Cart, API, 7.62mm, in cartons, grade R	1,200	86	-----	1.28	-----	33	-----
Cart, B&T, cal .30, w/b, 250 rd mg chest	1,000	77	-----	.9	-----	26	-----
Cart, B&T, cal .30, web belt	1,250	96	-----	1.5	-----	35	-----
Cart, B&T, cal .30, w/b	1,200	93	-----	1.5	-----	36	-----
Cart, B&T, 7.62mm, 100 rd belt	800	-----	-----	.91	-----	-----	-----
Cart, B&T, 7.62mm, 210 rd belt	840	-----	-----	.91	-----	-----	-----
Cart, B&T, 7.62mm, 220 rd belt	880	-----	-----	.92	-----	-----	-----
Cart, ball, cal .30 carbine	3,000	100	-----	.85	-----	19	-----
Cart, ball, cal .30 carbine	3,450	107	-----	.9	-----	19	-----

Nomenclature	Number per unit	Weight (lb)		Cubic feet		Stowage factor	
		Crated	Uncrated	Crated	Uncrated	Crated	Uncrated
Cart, ball, cal .30, 8 rd clip	1,344	110		1.5		31	
Cart, ball, cal .30, 5 rd clip	1,440	117		1.5		29	
Cart, ball, cal .30, 5 rd clip	1,500	114		1.5		29	
Cart, ball, cal .30, in cartons	1,500	111		1.5		30	
Cart, ball, cal .45, in cartons	1,800	97		.8		19	
Cart, ball, cal .45, in cartons	2,000	111		1.0		20	
Cart, ball, cal .50, in cartons	350	107		1.5		31	
Cart, ball, 7.62mm, linked, grade MG	880	78		.92		26	
Cart, ball, 7.62mm, in cartons, grade R	960	72		.91		28	
Cart, ball, 7.62mm, in cartons, grade R	1,200	86		1.28		33	
Cart, grenade, cal .30, M3	2,000	90		1.5		37	
Cart, inc, cal .50, in cartons	350	108		1.5		31	
Cart, tracer, cal .30, in cartons	1,500	108		1.5		31	
Cart, tracer, cal .30, 5 rd clip	1,500	114		1.5		29	
Cart, tracer, cal .30, 8 rd clip	1,440	117		1.5		29	
Cart, tracer, cal .50, in cartons	350	111		1.5		30	
Cart, tracer, 7.62mm, in cartons, grade R	1,200	86		1.28		33	
Cart, tracer, 7.62mm, M62 in cartons, grade R	400	28		.54		43	
Cart, tracer, 7.62mm, M62 in cartons, grade R	960	72		.91		28	
Cart, tracer, 7.62mm, M62 in cartons, grade R	1,040	78		1.28		37	
Cart, 12 ga, No. 00 buckshot	500	62		.768		28	
Cart, 12 ga, No. 7 1/2	500	58		.768		30	
Cbg, prop, M1A1 (green bag) 155H	6	67	40	3.08	1.91	103	107
Chg, prop, M3 (green bag) 155H	6	82	53	3.33	2.68	91	114
Chg, prop, M2 (white bag) 155H	6	82	73	3.26	2.63	89	81
Cbg, prop, M4 (white bag) 155H	3	79	58	3.92	2.5	111	97
Chg, prop, 155G, 1917-17A1-18M1	1	87		3.0		77	
Chg, prop, 155G, M1917-17A1-18M1	3	131	105	4.96	4.19	85	89
Chg, prop, 155G, M1917-17A1-18M1	4	191		7.08		83	
Ch, prop, 155G, M1 & M1A1	3	161	127	7.44	5.15	104	91
Fuze, PD, M46	50	51		.89		39	
Fuze, PD, M47	50	53		.89		38	
Fuze, PD, M51, M51A1, M55, M55A1	25	83		1.46		39	
Fuze, PD, M.T., M67	25	78		1.46		42	
Fuze, det, M6A2	200	64		2.50		88	
Fuze, ing, M10A2	200	64		2.7		95	
Grenade, AT, M11A1, prct	50	87		3.3		85	
Grenade, hand, frg, Mk II	25	50		1.26		57	
Grenade, band, off (unfuzed)	50	50		1.37		62	
Grenade, hand, tug, Mk, 1 A1	24	47		.97		46	
Grenade, rifle, M9 and M9A1	10	32		1.2		83	
Grenade, rifle, prct, M11	50	108		2.8		58	
Mine, AP, M2, M2A1	10	93.4		2.33		56	
Mine, AP, M3	6	75		.80		24	
Mine, AT, M1, prct	5	68		1.45		48	
Mine, AT, M1A1	5	73		1.45		45	
Primer, DTE, M14, 1-sec delay	100	67		1.01		34	
Primer, perc, Mk 11, Mk 11A, Mk 11A1	2,400	96		1.56		36	
Shell, AP, M112B1, 155G	1	117		1.34		26	
Shell, all other 155mm	1		96		.83		19
Shell, HE, M1, w/f M48, 105mm H	3	172	154	2.37	2.06	31	30
Shell, HE, M43A1 (lt) 81mm, M	6	72	58	1.65	1.08	51	42
Shell, HE, M48, w/f M48, 75 GNC	3	82	68	1.84	1.03	50	34
Shell, HE, M48, w/f M48, 75 GNC	3	84	70	1.84	1.03	50	33

Nomenclature	Number per unit	Weight (lb)		Cubic feet		Stowage factor	
		Crated	Uncrated	Crated	Uncrated	Crated	Uncrated
Shell, HE, M48, w/f M48, 75 H	3	80	69	1.35	.92	38	30
Shell, HE, M48, w/f M54, 75 GNC	3	82	68	1.84	1.03	50	34
Shell, HE, M48, w/f M54, 75 GNC	3	84	70	1.84	1.03	50	33
Shell, HE, M48, w/f M54, 75 H	3	80	69	1.35	.92	38	30
Shell, HE, M49A2, 60mm, M	18	103	82	3.23	2.51	70	69
Shell, HE, M56 (hv), 81mm, M	3	55	42	1.33	.91	54	49
Shell, HE, M63, 37mm, G	20	91		2.04		50	
Shell, HE, M71, 90mm, G	4	237		4.43		42	
Shell, HE, N54, 37mm, G	25	99		2.03		46	
Shell, HE, Mk 1 (Navy), 40mm, G	16	115		1.80		35	
Shell, HE, Mk 11, 37mm, G	60	114		1.60		31	
Shell, HE, w/f, M54, 105 H	3	172	154	2.37	2.06	31	30
Shell, HE, 3" AA G	4	153		3.22		47	
Shell, QF, Mk II, 40mm, G	24	161		3.13		44	
Shell, prct, Mk II, 37mm, G	40	90		1.38		34	
Shell, prct, M50A2, 60mm, M	18	103	82	2.23	2.51	70	69
Shell, Mk I, unfuzed, 75 G	3	72	57	1.72	.96	54	38
Shell, 8", G	1		386				
Shell, 8", how	1		163				
Shell, 280mm, G	1		770				
Shot, AP, M78, 3", AA G	4	153		3.22		47	
Shot, AP, M51, 37mm, G	20	104		2.01		43	
Shot, AP, M74, 37mm, G	20	91		1.01		50	
Shot, AP, M72, 75 G	3	80	66	1.51	.83	28	28
Shot, AP, M77, 90mm, G	4	237		4.43		42	
Shot, APC, M59, 37mm, G	25	99		2.03		46	
Shot, APC, M61, 75mm, G.S.C.	3	83	70	1.84	1.03	50	33
Shot, LE, Mk I, 37mm, G	60	105		1.38		29	
Signal, ground, M17 to M22	61			1.85			
Signal, Very, red & white, Mk II	31			.92			
Signal, Very, red & green star, Mk II	103			2.57			
Smoke, WP, M60 105 H	3	172	159	2.37	2.06	31	29
Smoke, WP, M64, 75H	3	82	70	1.66	.92	45	29
Smoke, WP, M57, 81mm, M	3	55	45	1.65	.91	67	45
Smoke, WP, Mk II, unfuzed, 75 G	3	72	57	1.72	.96	54	38

c. Petroleum Products.

	Container	No. per unit	Weight (lb)	Cubic feet	Stowage factor
Aviation gasoline.	55-gal. drum, 18-gage steel.	1	373	9.03	54
	55-gal. drum, 16-gage steel.	1	389	8.8	51
	55-gal. drum, 18-gage light steel.	1	364	9.2	56.5
	5-gal. can, 11-lb can.	1	40.5	.81	44.8
83 octane gasoline.	55-gal. drum, 18-gage steel.	1	384	9.03	52.7
	55-gal. drum, 16-gage steel.	1	200	8.8	49.2
	55-gal. drum, 18-gage light steel.	1	376	9.2	55
	5-gal. can, 11-lb can.	1	41.6	.81	43.6

	Container	No. per unit	Weight (lb)	Cubic feet	Stowage factor
Kerosene.	55-gal. drum, 18-gage steel.	1	421	9.03	48.1
	55-gal. drum, 16-gage steel.	1	437	8.8	45.1
	55-gal. drum, 18-gage light steel.	1	351	9.2	58.8
	5-gal. can, 11-lb can.	1	45	.81	40.4
Diesel fuel.	55-gal. drum, 18-gage steel.	1	432	9.03	47
	55-gal. drum, 16-gage steel.	1	448	8.8	44.2
	55-gal. drum, 18-gage light steel.	1	430	9.2	47.9
	5-gal. can, 11-lb can.	1	46	.81	39.5
Lubricating oils.	55-gal. drum, 18-gage steel.	1	472	9.03	42.8
	55-gal. drum, 16-gage steel.	1	488	8.8	40.5
	55-gal. drum, 18-gage light steel.	1	462	9.2	44.6
	5-gal. can, 11-lb can.	1	49	.81	37.1
	Cases of 1-qt cans, 12 per case (crated).	12	35	.88	56.6
	Cases of 1-qt cans, 24 per case (crated).	24	60	1.6	60
	Cases of 5-qt cans, 6 per case (crated).	6	77	1.9	55.7
Grease.	25-lb pails.	1	29	.95	73.6
	5-lb cans, 6 per case (crated).	6	44	1.1	56

7.33 Annealed Wire

Gage No.	Diameter (in.)	Tensile strength (lb)
7	$\frac{3}{16}$	1,100
8	$\frac{11}{64}$	950
9	$\frac{5}{32}$	800
11	$\frac{1}{8}$	500

7.34 Rods and Bolts

Diameter (in.)	Tensile strength* (lb)
$\frac{1}{2}$	5,200
$\frac{5}{8}$	8,100
$\frac{3}{4}$	11,700
1	21,100
$1\frac{1}{8}$	25,800
$1\frac{1}{4}$	32,800
$1\frac{3}{8}$	38,600
$1\frac{1}{2}$	46,900

* At root of thread.

7.35 Common Nails

Type	(Length (in.))
8-penny.....	2½
9-penny.....	2¾
10-penny.....	3
12-penny.....	3¼
16-penny.....	3½
20-penny.....	4
30-penny.....	4½
40-penny.....	5
50-penny.....	5½
60-penny.....	6

7.36 High-Tension Bands

Width and thickness (in.)	Tensile strength (lb)
$\frac{3}{8} \times 0.050$	2,000
$\frac{3}{4} \times .028$	2,000
$\frac{3}{4} \times .030$	2,000
$\frac{3}{4} \times .035$	2,500
$\frac{3}{4} \times .037$	2,500
$\frac{3}{4} \times .050$	3,500

Width and thickness (in.)	Tensile strength (lb)
1¼ × .035-----	4,000
1¼ × .037-----	4,000
1¼ × .050-----	6,000
2 × .050-----	9,500

7.37 Supply-Planning Terms

a. Consumption Rate. The average quantity of an item consumed or expended during a given time interval, expressed in quantities per applicable basis.

Section IX. STORAGE AND MAINTENANCE SPACE

7.38 Storage

a. Gross Storage Area: Average Ratio of Open to Covered by Classes of Supply.

	Ratios of gross storage area	
	Open	Covered
All classes (except bulk POL)-----	5.5	1
Classes I, II, III (packaged and solid), and IV	4.7	1
Classes I, II, III (packaged), and IV-----	3	1
Class V (including 10 percent of V-A)-----	12	1

b. Average Stack Height. Figures given are for use of all technical services in theaters of operation. For CONUS storage, the figures must be increased 25 percent.

(1) Covered storage—8 feet (2.4 meters).

(2) Open storage—6 feet (1.8 meters).

c. Miscellaneous Data.

Ammunition storage per mile (1.6 km)

of road¹-----1,000 short tons

Ammunition storage per square mile¹-----5,000 short tons

Minimum hardstand for 2,500 vehicles²-----110,000 square feet

Solid footing for vehicle park for 2,500

vehicles-----4,000,000 sq ft

Minimum hardstand for artillery and

combat vehicles, per item-----350 square feet

¹ Refers to temporary storage of ammunition along roadways and in urban fields and forests, such as may be found in combat zones.

² Data based on the assumption that hardstand area will not be required for the total number of vehicles at any one time.

Section X. FIELD ESTABLISHMENTS AND EXPEDIENTS

7.40 Bivouacs and Camps

(fig. 7.7).

a. Definitions. Bivouacs are occupied less than 1 week and have temporary sanitation facilities. Camps are occupied more than 1 week and provide better bathing, sanitation, administration, security, and recreational facilities.

b. Size. Fifty square yards are allowed per man; 100 square yards per vehicle. If air attack is probable, at least 100 yards (91 meters) is maintained between dispersed vehicles; no extra

b. Day of Supply. That quantity of supplies estimated to be required for 1 day under the conditions of the operation and for the force stated.

c. Replacement Factor. A number expressed as a decimal which, when multiplied by the total projected quantity of an item in use, gives the quantity of that item required to be replaced during a given period of time.

d. Slice. An average logistical planning factor used to obtain estimates of requirements for personnel and materiel.

7.39 Covered Shop Floor Space

	Sq m	Sq ft
Ordinance:		
Armament rebuild battalion-----	9,290	100,000
Automotive rebuild battalion-----	9,290	100,000
Direct automotive maintenance com-		
pany-----	2,323	25,000
Direct support company-----	1,858	20,000
Guided missile depot support shop--	1,208	13,000
Guided missile direct support shop--	1,208	13,000
Guided missile heavy support shop--	1,208	13,000
Heavy automotive maintenance com-		
pany-----	3,716	40,000
Heavy maintenance company, field		
army-----	2,787	30,000
Motor vehicle assembly company--	1,858	20,000
Tire repair company-----	1,486	16,000

Transportation:

Heavy truck company-----	474	5,100
Light truck company-----	344	3,700
Medium truck company-----	520	5,600
Railway operating battalion-----	2,601	28,000
Railway shop battalion-----	3,716	40,000

allowance is made for personnel. Dispersion of 50 yards (46 meters) between vehicles requires 2,500 square yards per vehicle; 100 yards between vehicles requires 10,000 square yards per vehicle. (To obtain meters, multiply feet given below by .3048.)

c. Location.

(1) *Desirable.*

(a) Concealment from air observation.

(b) Shade trees for sun protection.

(c) Protected slope or trees for windbreaks in cold weather.

- (d) Firm, grass-covered turf.
- (e) Firm ground for vehicles.
- (f) Good road net.
- (g) Elevated, well-drained site.
- (h) Access to sufficient amount of good water.
- (i) Sandy loam or gravel soil, favorable to waste disposal.
- (j) Sufficient space to avoid crowding and to permit wide space between kitchens and latrines.

(2) *Undesirable.*

- (a) Dry beds of rivers, ravines, or depressed areas in rainy country.
- (b) Clay or loose, dusty soil.
- (c) Marshy ground or areas near water which may be infested by mosquitoes and subject to mist or heavy dew.
- (d) Ground water level less than 4 feet from the surface of the ground.
- (e) Steep slopes.
- (f) Within a mile of native villages in tropical or subtropical climates.
- (g) Low areas during periods of extreme cold.

d. Latrines. Locate on side of camp opposite prevailing wind, at least 100 yards from kitchen and water supply, 30 yards from nearest tents, and place to drain away from water supply.

- (1) *Straddle trench.* Used for bivouacs only. Dig 1 foot wide by 2½ feet deep by 8 feet long for use of 50 men. Individuals cover refuse immediately. Oil daily. Close when refuse is within 1 foot of surface or when abandoned.
- (2) *Deep pit.* Used for temporary camps. Dig 2 feet wide by 8 feet long by 3 to 10 feet deep. Depth should be 2 feet plus 1 foot for each week of occupation. Should be equipped with fly-proof latrine box.
- (3) *Pail latrine.* Used where soil characteristics prevent digging latrine convenient to camp or bivouac.
- (4) *Urinal soakage pit.* Used throughout camps and work areas. A pit 4 feet square by 4 feet deep filled with broken rock or brick serves 200 men indefinitely. Provide funnels on basis of 1 per 20 men.

e. Washing Facilities. Locate between tents and latrines. Ten feet of wash bench should be provided per 100 men. Showers should be provided where practicable, on basis of 1 shower head

per 25 men; in tropics and in temperature zones during summer, the ratio should be 1 shower head per 20 men. See FM 21-10 for methods of constructing expedient showers.

f. Kitchens. Locate at opposite end of area from latrines. One soakage pit with barrel or baffel grease trap should be provided for each 200 men. If area is occupied more than 2 weeks, a second pit should be installed (FM 21-10).

g. Water Supply.

Condition	Gallons per man per day ¹	Remarks
Temperate zones: ²		
Combat-----	½	Minimum for no longer than 3 days. Used for drinking.
	1	Some allowance for cooking and personal hygiene.
March or bivouac-----	2	Minimum. Enough for drinking and cooking, washing mess and kitchen utensils, washing hands and face.
	5	Should be supplied if possible; permits laundry and possibly some bathing.
Camp-----	5	Minimum. Does not include bathing or sewerage facilities.
	15	Includes conservative bathing.
	30	Permits waterborne sewerage.
Desert areas:		
Emergency (traveling at night and resting in shade during day).	½	Such a ration should not continue for more than 5 days. Used for drinking only.
Normal march or combat (day and night operations).	¾	Ration is considered minimum for day and night conditions for not more than 5 days. Used for drinking only.
	1¼	This ration permits drinking, limited cooking, careful washing of mess gear, shaving, brushing teeth.

¹ For well-trained troops.

² In northern areas, the water requirements per man per day will be comparable to rates for temperate zones.

h. Closing Camp and Bivouac. Before leaving site, close all sanitary installations, fill in latrines

and soakage pits, erect markers indicating CLOSED LATRINE, etc.

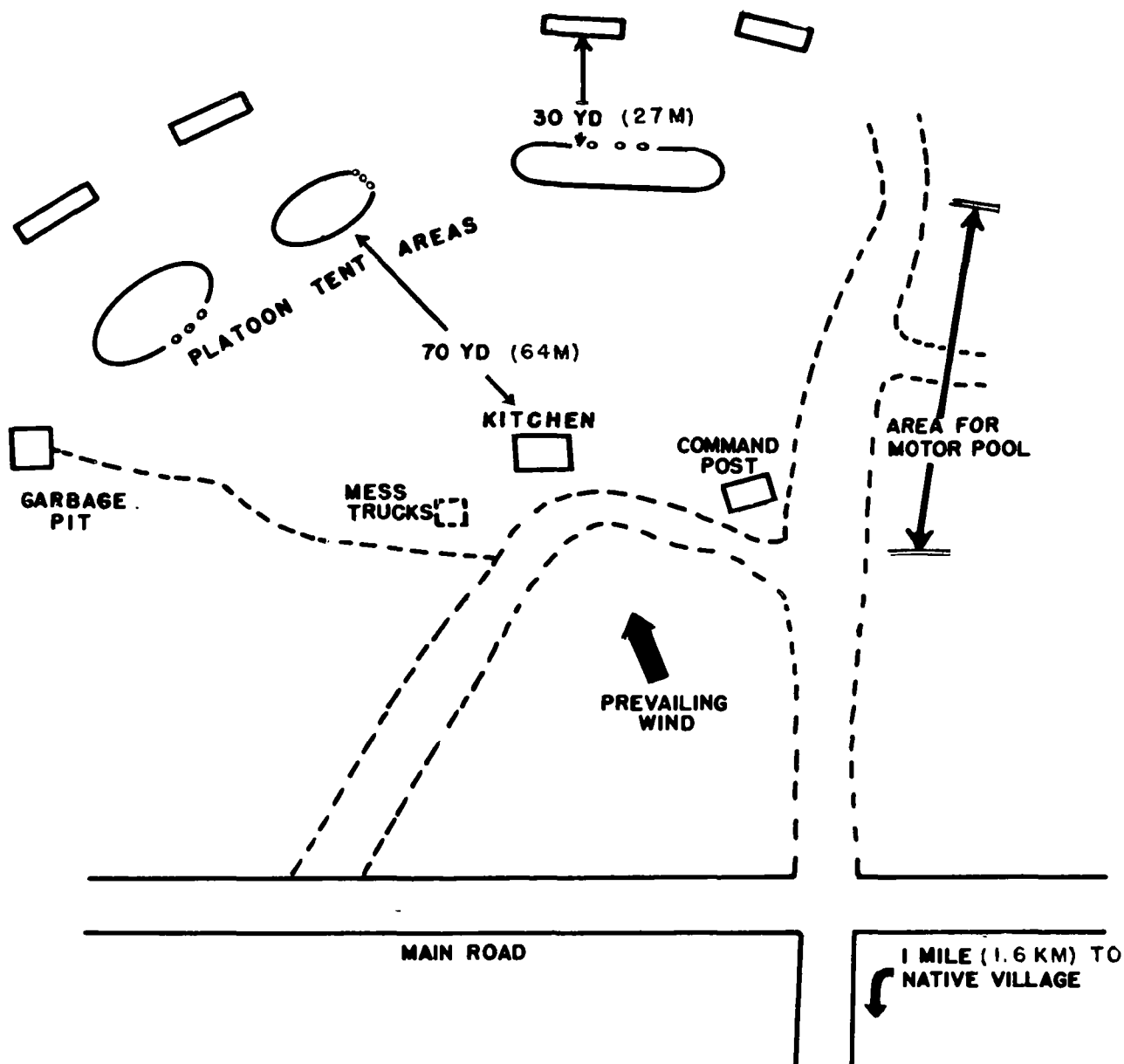


Figure 7.7. Administrative company bivouac area.

7.41 Tentage

Type	Shape of floor	Size						Number ^a men accommodated	Weight (lb)		Total weight (lb)	Storage bulk (cu ft)		Total cube, packed (cu ft)	Material	Doors		Ventilation		Stove-pipe or heater openings	Liner	Pitching ^b		Striking ^b	
		Floor dimensions (in.)	Total ground perimeter (in.)	Height		Surface area (sq ft)	Floor space (sq ft)		Tent only	Pins, poles		Tent only	Pins, poles			No.	Height (in.)	No. of openings	No. of windows			No. men	Time (min)	No. men	Time (min)
				Ridge (in.)	Side wall (in.)																				
Tents:																									
Arctic, 10-man	Hexagon	210 dia	630 ^a	102	35	316	199	10	68	3	76	7.1	0.2	7.3	9 oz OD cotton	2	60	4	0	1	Yes	5	27	5	15
Assembly.....	Rectangular plus rounded ends	430×950	2,457	252	96	4,955	2,357	30	1,100	655	1,755	23.3	15.9	40.2	9.3 and 12.3 oz duck	4	96	4	0 ^d	4	No	9	90	9	60
Balloon inflation.	Rectangle	159×132	632	143	(*)	335	201	3	110	333	443	-----	-----	61.4	9.3 oz duck	2	143	1	4	1	No	4	30	4	20
CP, M1942.....	Rectangle	84×142	452	84	72	328	84	2	112	104	215	6.0	3.7	8.7	12.3 oz duck	1	72	1	3	1	Yes	4	20	4	15
CP, M1945.....	Octagon	120×247 ^f	627	108	66	406	172 ^f	3	155	92	257	5.3	3.5	9.9	12.3 oz duck	1	72	1	3	1	Yes ^g	5	20	5	15
Fly, aquad.....	Rectangle	240×451	1,382	144	53	1,673	750	15	190	52	252	4.3	5.0	9.3	9 oz duck										
Fly, ward, hosp.	Rectangle	240×643	1,775	144	53	2,216	1,030	27	225	101	326	7.6	4.5	12.1	9 oz duck										
GP, large.....	Rectangle	216×624	1,580	144	56	2,035	936	21	420	245	555 ^h	21.0	7.7	59.0	12.3 oz duck	2	72	2	8	3	Yes	5	75	5	50
GP, medium.....	Rectangle	192×396	1,176	120	66	915	523	12	255	200	455 ⁱ	12.7	5.3	19.0	12.3 oz duck	2	72	2	5	2	Yes	4	40	4	30
Hexagonal, M1950.	Hexagon	159 dia	477	102	24	213	113	5	40	3	43	3.5	0.2	8.8	9 oz plied yarn and sateen cotton cloth	1	60	2	0	1	Yes	6	15	5	10
Hoospital, sectional.	Rectangle	216×635 ^k	1,704	144	72	2,170	954 ^k	24 ^l	770	327	1,097	31.6	12.2	48.7	12.3 oz duck except floor (9.3 oz duck)	2	72	2	16	3	Yes	9	90	9	70
Hospital, ward.	Rectangle	192×600	1,684	144	54	2,162	800	20 ^l	390	269	649	20.6	9.6	30.1	12.3 oz duck	2	54	2	14	3	Yes	9	90	9	70
Kitchen.....	Rectangle	144×215	720	144 ^m	72	831	216	10	203	217	420	14.2	12.0	25.2	12.3 oz duck	1	72	Ventilator Screens ^a		0	No	5	50	5	45
Maint, shelter	Rectangle	213×322	1,080	154	55	1,806	437	11	500	755	1,255	25.3	53.0	34.3	12.3, 9.8, and 6 oz duck	2	164	2 ^o	0	4	No	10	75	10	50
Mountain.....	Rectangle	54×32	272	43	12	112	81	2	5	4	10	0.5	0.2	0.7	Lightweight cotton and synthetic fiber	2	27 dia (p)	2	0	0	No	2	10	2	5
Oper, surgical..	Rectangle	192×324	1,032	144	84	1,190	432	10	252	75	327	10.3	8.5	18.8	9.8 and 12.3 oz duck	2	84	2	8	2	Yes	4	40	4	30
Oper, surgical, hv.	Rectangle	215×548	1,728	183	72	2,053	972	22	817	875	1,593	38.8	23.2	62.0	9.3 and 12.3 oz duck	2	72	2	15	8	Yes	9	90	9	70
Pyramidal.....	Square	192×192	768	144	53	395	256	5	180	94	224	5.2	3.5	9.8	12.3 oz duck	1	63	1	0	1	No	5	20	5	15
Pyramidal, lightweight.	Circle	132 dia	414	102	24	182	95	4	87	2	39	2.5	0.2	2.7	12.3 oz duck	1	-----	2	0	1	No	6	15	5	10
Squad, M1942..	Rectangle	192×384	1,152	144	54	885	512	12	255	147	402	10.9	5.9	16.3	9.8 and 12.3 oz duck	2	54	2	-----	2	No	4	40	4	30
Squad, M1945..	Rectangle	192×384	1,152	144	54	336	512	12	275	150	425	11.1	6.1	17.2	12.3 oz duck	2	54	2	-----	2	Yes	4	40	4	30
Storage.....	Rectangle	214×241	910	156	63	1,008	358	8	200	202	402	9.6	9.2	18.8	12.3 oz duck	2	53	2	-----	-----		4	40	4	30
Wall, large.....	Rectangle	168×174	684	132	54	670	208	8	180	146	275	6.8	8.1	8.9	12.8 and 9.8 oz cotton duck	2	132	2	0	(*)	No	4	30	4	20

Wall, small.....	Rectangle	106×110	432	102	45	284	81	2	55	60	115	3.4	4.1	7.5	12.3 and 9.8 oz cotton duck	2	102	2	0	(a)	No.	4	30	4	20
Paulins: r																									
Fly, storage.....	-----	300×245	-----	-----	-----	512	-----	-----	85	20	105	2.8	0.8	3.6	9.8 oz duck										
Fly, wall, small.....	-----	186×110	-----	-----	-----	142	-----	-----	23	15	38	3.1	0.7	3.8	9.8 oz duck										
Large.....	-----	240×480	-----	-----	-----	800	-----	-----	250	-----	250	6.7	-----	6.7	9.8 oz duck										
Medium.....	-----	192×384	-----	-----	-----	512	-----	-----	160	-----	160	4.2	-----	4.2	9.8 oz duck										
Screen, latrine.....	(*)	216×108× 84 *	660	-----	72 *	292	144	(u)	32	-----	32	0.8	-----	0.8	9.7 oz duck	1	-----	-----	-----	-----	No	6	20	6	15
Small.....	-----	144×204	-----	-----	-----	204	-----	-----	57	-----	57	2.3	-----	2.3	9.8 oz duck										

* If used as a field billet.

b Average for normal conditions.

c Six equal sides of 105 inches each.

d Tent also ventilated by lifting sidewalls.

e Arched top.

f The two measurements shown are the longest dimensions, including vestibule (trapezoid measuring 120" × 48" × 89.5" × 89.5").

g Liner does not cover vestibule.

h Liner weighs additional 155 pounds.

i Includes tent, liner, pins, and poles.

j Liner weighs additional 90 pounds and occupies a stored cubage of 8 cubic feet.

k Does not include vestibules at each end, which measure 48" × 90".

l Bed patients on cots.

m Height shown is for stack section. Service section is 108 inches high.

n Ventilator screens on all sides of the service and stack sections, to be used as required.

o Plus one large opening (120" × 120") in roof.

p Tubular tunnel entrance, 24 inches long.

q Either of the ventilator openings may be used as stovepipe opening.

r Dimensions shown for flies and paulins are length and width.

s Screen has a 3-foot overlap on one side for an entrance.

t Bottom edge of screen normally 9 inches off ground.

u One for average company-size unit.

7.42 Water Purification

a. Distillation. Stills can be built to produce drinkable water from impure water by using a source of heat, a method of forming and collecting steam, and some kind of condenser. (The still in figure 7.8 has a water-cooled condenser.) The efficiency of an expedient still depends on the materials available and the ingenuity of the designer. In expedient distillation, sufficient vapor-separating space must be provided to prevent the carryover of salt in the distillate with the steam. To avoid endangering personnel by the building up of excessive steam pressure, a valve must never be put in the distillate line.

b. Chlorination. The purification of water with chemicals is known as chlorination. Halazone tablets or iodine water purification tablets, chemicals in the Army supply system, may be used as directed on containers. Calcium hypochlorite, with 70 percent available chlorine, may also be used. One ounce per 1,000 gallons of water, allowed to stand for 2 hours, will purify most waters.

c. Filtration. Much of the pollution in water can be removed by filtration through sand or anthracite coal. The depth of beds for both materials is usually 24 to 30 inches. Dry sand

weighs approximately 92 pounds per cubic foot. Wet anthracite coal weighs approximately 60 pounds per cubic foot. Average yield of a sand filter is 2 gallons per minute per square foot of filter surface. Water should be tested for bacteria content after filtration.

d. Boiling. In low altitudes, practically all of the bacteria in water can be destroyed by boiling for 10 minutes; at high altitudes, where water boils at a reduced temperature, boiling time should be doubled.

e. Aeration.

- (1) Many natural waters are improved by aeration, which is a process whereby the water is broken up and brought into intimate contact, with air. This process accomplishes the following:
 - (a) Removes or reduces undesirable gases, such as carbon dioxide, hydrogen sulphide, excess chlorine, and marsh gas.
 - (b) Adds oxygen.
 - (c) Removes odors, such as those caused by decomposition, microscopic organisms, organic matter, and trade wastes.
 - (d) Aids in other water purification processes, such as coagulating, mixing chemicals, removing iron and manga-

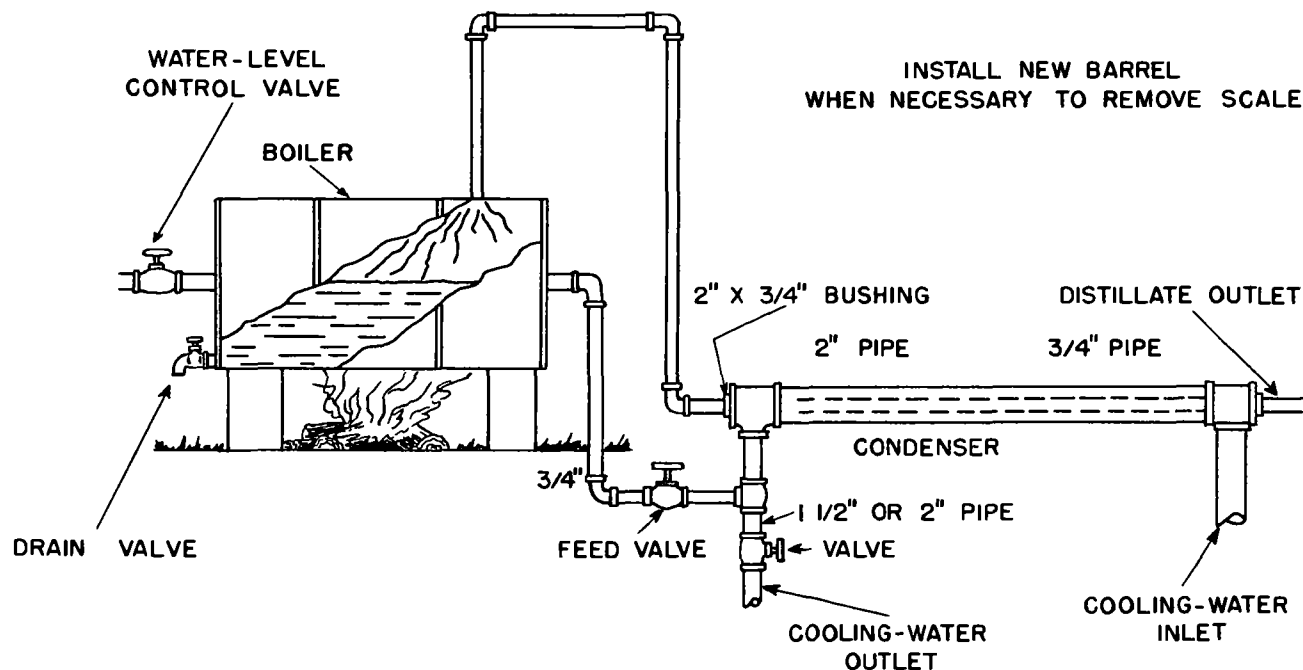


Figure 7.8. Expedient still, water-cooled condenser.

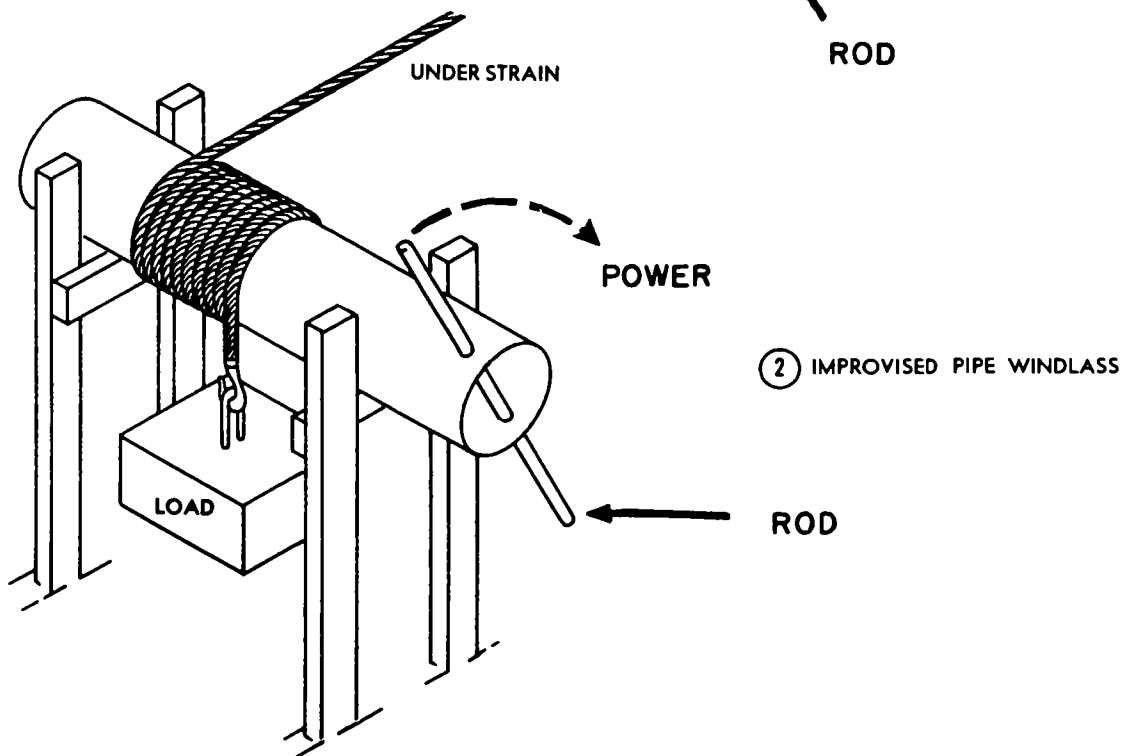
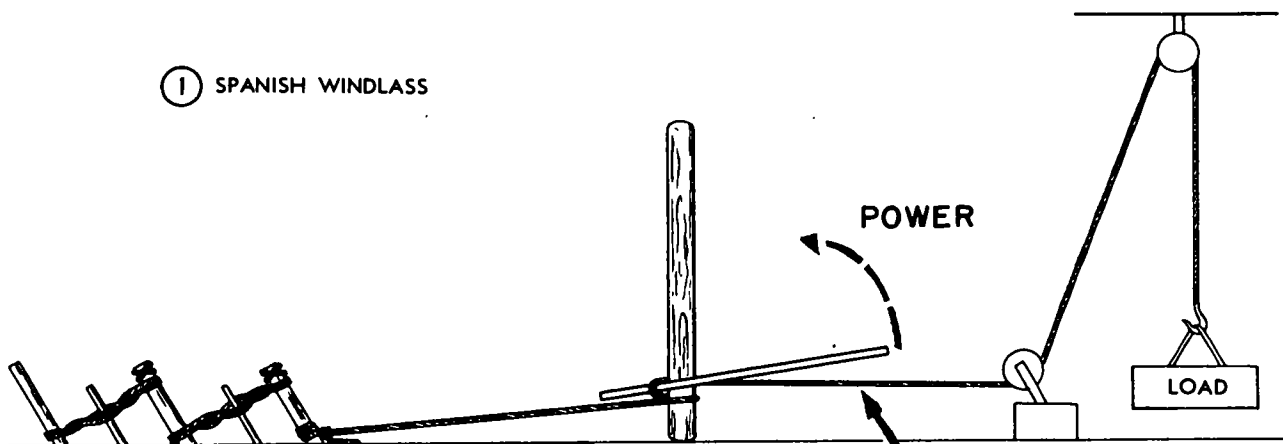


Figure 7.9. Expedient rigging for hoisting.

nese, freshening stagnant water, breaking up microscopic organisms.

(2) Aeration methods in order of effectiveness are:

- (a) Fine spray from nozzles.
- (b) Cascades over steps, riffles, or weirs.
- (c) Trickling devices (coke or stone beds).
- (d) Use of mechanical means to draw air into the water or inject air under pressure.

f. Sedimentation. Still water, such as that found in ponds and lakes or in reservoirs, becomes partly clarified and purified by the settling of suspended solids and the bleaching and germ-killing action of sunlight. Time and stillness are the important factors. Surface and internal currents must be avoided; the retention period must be long enough for the water to become purified.

7.43 Hoists

(fig. 7.9)

An expedient hoist, such as a windlass or the twisting of an endless rope, can be readily as-

sembled from equipment usually available in the field. Figure 7.9 shows how to move loads a short distance vertically and horizontally. In 1, figure 7.9, the upright post is not anchored because it must turn when rotary power in a horizontal plane is applied to the rod. In 2, figure 7.9, as rotary power in a vertical plane is applied to the rod, only sufficient tension need be applied at the "under strain" point to cause static friction; therefore, there is no slippage between the rope and the pipe. A method of moving heavy loads a short distance horizontally is illustrated in 3, figure 7.9.

7.44 Shears

(fig. 7.10)

Shears serve the same purpose as an A-frame, and can be used to support a block and tackle arrangement as illustrated in figure 7.12.

7.45 Gin Poles

(fig. 7.11)

A gin pole serves the same purpose as an A-

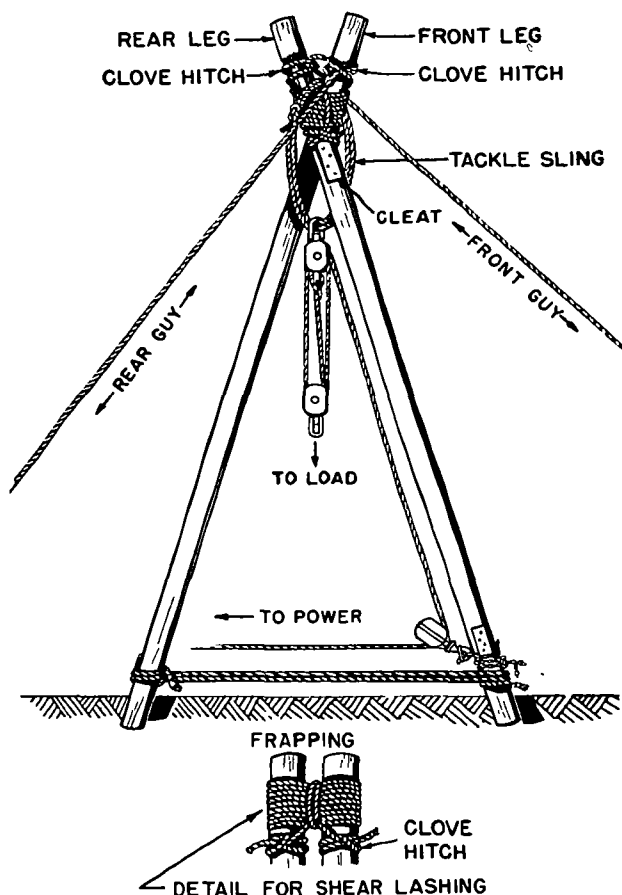


Figure 7.10. Shears.

frame. It is an inclined pole that has a sufficient number of guys to hold it in a stationary position. Figure 7.11 illustrates this type of mechanical arrangement in use.

7.46 Cableways

(fig. 7.12)

An expedient cableway can be used to transport supplies across a small canyon or stream or to the top of a ridge. It can be made by using two shears, two pulleys, a cargo hook, a vehicle, ropes, and stakes. Figure 7.12 illustrates one method of

erecting an expedient cableway using a $\frac{1}{4}$ -ton truck as the power source. To construct a cableway:

- Jack up one wheel of a $\frac{1}{4}$ -ton truck and remove the tire.
- Take a rope about 10 percent longer than twice the straightline distance between the summit of the ridge and the truck.
- Run the rope through pulleys anchored at both the top and bottom of the ridge, and around the rim of the wheel.
- Splice the ends of the rope together and suspend a cargo hook from it.

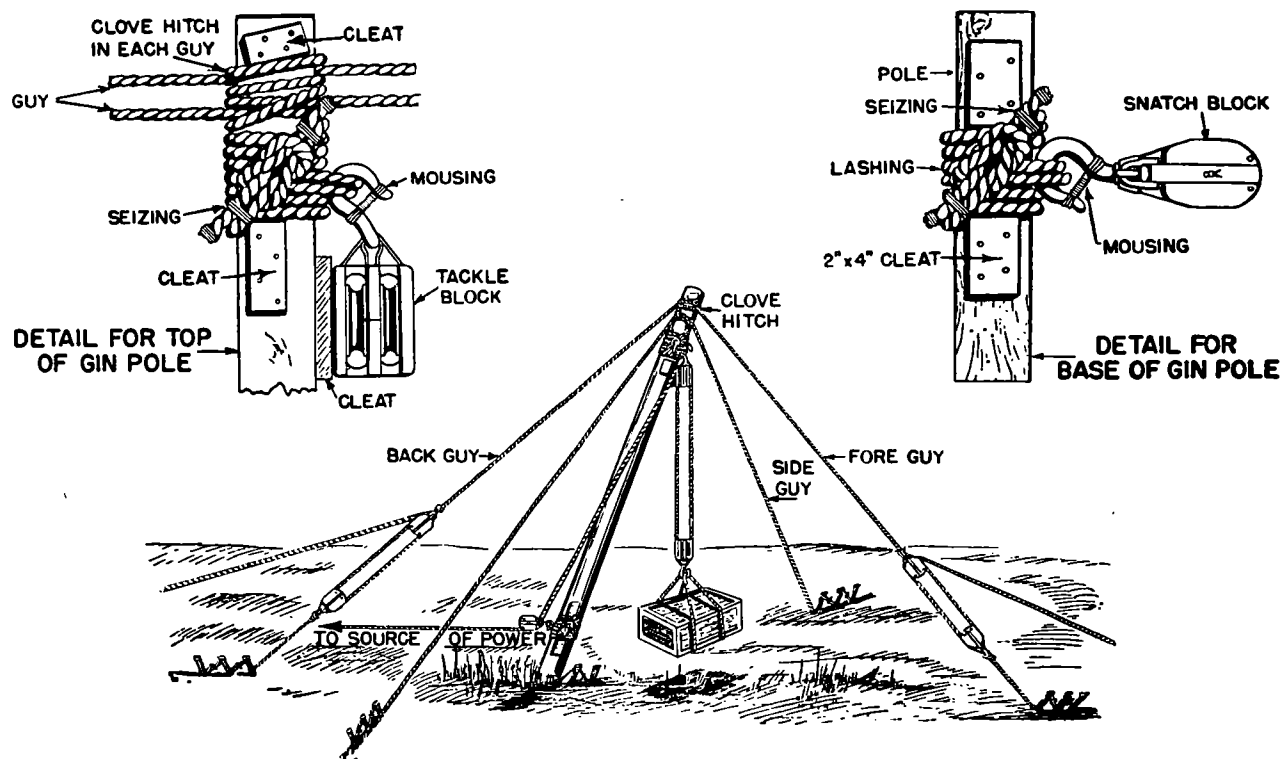


Figure 7.11. Gin pole.

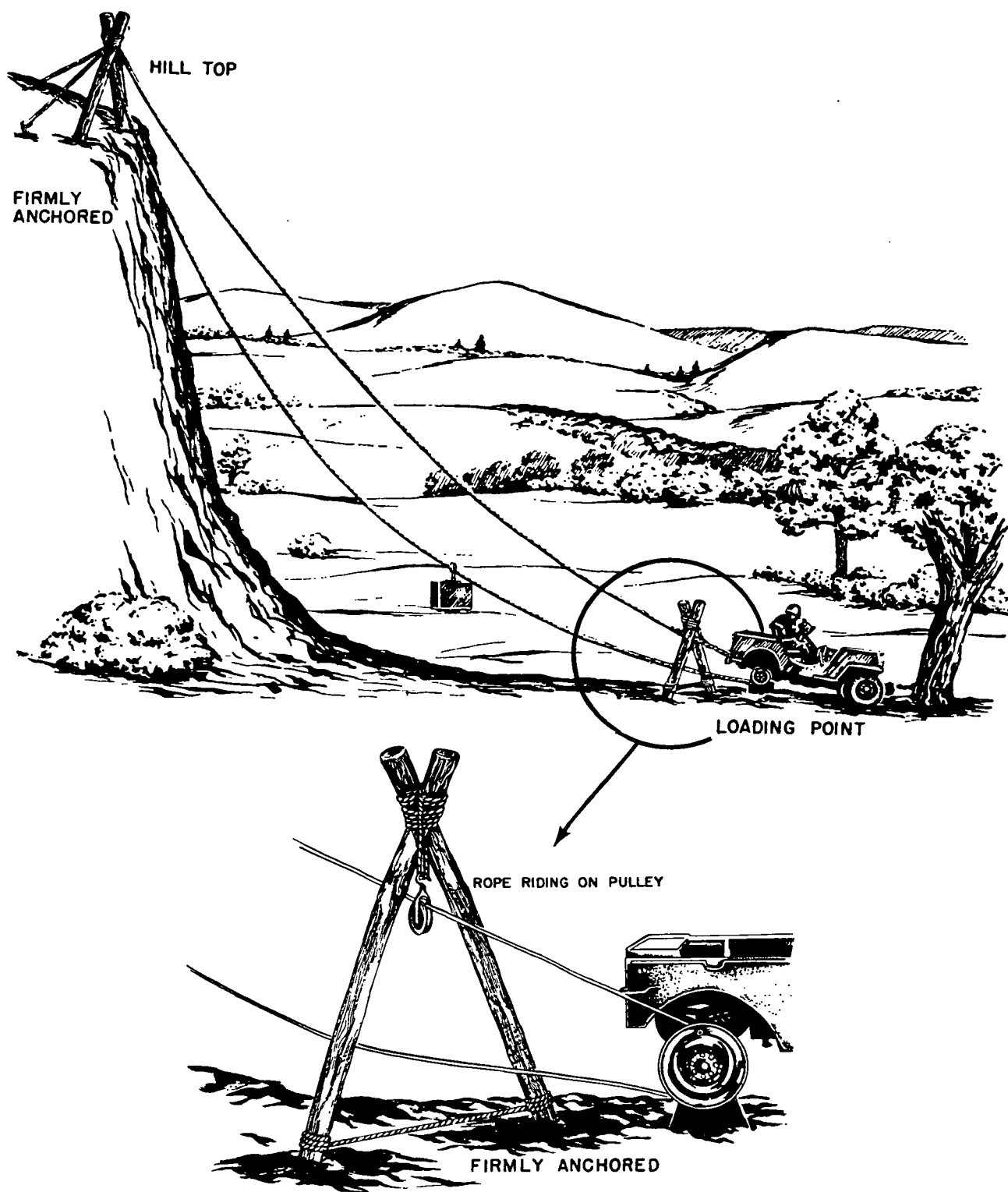


Figure 7.12. Expedient cableway, powered by a $\frac{1}{4}$ -ton truck.

Section XI. CONVERSION FACTORS

7.47 Conversion Factors

a. Linear Measure.

Meters*	Inches	Feet	Yards	Rods	Chains	Miles		Kilometers	Cables' lengths	Fathoms
						Statute	Nautical**			
1.0	39.37	3.28083	1.09361	0.19884	0.04971	0.0006214	0.0005396	0.001	0.00454	0.546
.0254	1.0	.0833	.0278	.00505	.00126	.00001578	.00001371	.0000254	.000116	.0139
.3048	12.0	1.0	.3333	.0606	.0151	.0001894	.0001645	.0003048	.00139	.167
.9144	36.0	3.0	1.0	.1818	.04545	.0005682	.0004934	.0009144	.00417	.500
5.0292	198.0	16.5	5.5	1.0	.25	.003125	.002714	.005029	.0228	2.76
20.1168	792.0	66.0	22.0	4.0	1.0	.0125	.01085	.02012	.091	11.0
1,609.35	63,360.0	5,280.0	1,760.0	320.0	80.0	1.0	.8684	1.6094	7.32	879.0
1,853.25	72,962.5	6,080.2	2,026.73	368.497	92.1243	1.15155	1.0	1.85325	8.46	1,010.0
1,000.0	39,370.0	3,280.83	1,093.61	198.838	49.7096	.6214	.5396	1.0	4.56	546.0
219.5	8,640.0	720.0	240.0	43.6	10.9	.1364	.1184	.2195	1.0	120.0
1.829	72.0	6.0	2.0	.363	.091	.00114	.00098	.00183	.00835	1.0

* 1 meter = 10 decimeters = 100 centimeters = 1,000 millimeters

** A nautical mile is the length on the earth's surface of an arc subtended by one minute of angle at the center of the earth. Therefore, the circumference of the earth is equivalent in nautical miles to the number of minutes in a circle ($360 \times 60 = 21,600$).

b. Surface Measure.

Square meters	Square inches	Square feet	Square yards	Square rods	Acres	Hectares	Square miles (statute)	Square kilometers
1.0	1,550.0	10.764	1.196	0.03954	0.000247	0.0001	0.000000386	0.000001
.00065	1.0	.0069	.00077	.00000026	.00000016	.000000065	.00000000025	.00000000065
.0929	144.0	1.0	.1111	.00367	.00002296	.00000929	.0000000359	.0000000929
.8361	1,296.0	9.0	1.0	.0331	.0002066	.0000836	.000000323	.000000836
25.293	39,204.0	272.25	30.25	1.0	.00625	.000253	.00000977	.0000253
4,046.8	6,272,640.0	43,560.0	4,840.0	160.0	1.0	.4047	.00156	.00405
10,000.0	15,499,969.0	107,639.0	11,960.0	395.37	2.471	1.0	.00386	.01
2,589,999.0	Sq ft $\times$ 144	27,878,400.0	3,097,600.0	102,400.0	640.0	259.0	1.0	2.59
1,000,000.0	Sq ft $\times$ 144	10,763,867.0	1,195,985.0	39,537.0	247.1	100.0	.3861	1.0

c. Cubic Measure.

U. S. dry measure: 1 bushel = 4 pecks = 8 gallons = 32 quarts = 64 pints
 U. S. liquid measure: 1 gallon = 4 quarts = 8 pints = 32 gills = 128 fluid ounces = .83268 imperial gallon

Cubic centimeters	Cubic decimeters or liters	Cubic inches	Cubic feet ¹	Cubic yards	U. S. quarts		U. S. gallons		U. S. bushels	Measurement tons
					Liquid	Dry	Liquid	Dry		
1.0	0.001	0.061	0.0000353	0.0000013	0.001056	0.000908	0.000264	0.000227	0.000028	0.00000088
1,000.0	1.0	61.023	.0353	.00131	1.0567	.9081	.2642	.227	.0284	.000882
16.39	.01639	1.0	.0005787	.0000214	.0173	.0149	.00433	.00372	.00465	.0000144
28,317.0	28.317	1,728.0	1.0	.03704	29.922	25.714	7.481	6.4285	.80356	.025
764,559.0	764.559	46,656.0	27.0	1.0	807.896	694.279	201.974	173.57	21.696	.677
946.4	.9464	57.75	.03342	.00124	1.0	.8594	.25	.2148	.02686	.000837
1,101.2	1.1012	67.201	.03889	.00144	1.1636	1.0	.2909	.25	.0313	.000975
3,785.4	3.7854	231.0	.13368	.00495	4.0	3.4377	1.0	.8594	.1074	.00335
4,404.9	4.4049	268.803	.15556	.00576	4.6546	4.0	1.1636	1.0	.125	.00388
35,239.3	35.2393	2,150.42	1.2445	.0461	37.237	32.0	9.3092	8.0	1.0	.0312
1,130,000.0	1,130.0	69,120.0	40.0	1.48	1,190.0	1,030.0	298.0	256.0	32.2	1.0

¹ A board foot, used in measurements for lumber, measures 12" × 12" × 1". Its volume is 1/12 of a cubic foot.

d. Angular Conversions.

Circle	Radians	Degrees	Minutes	Seconds	Mils	Right angle	Straight line
1.0	6.2832	360.0	21,600.0	1,296,000	6,400.0	4.0	2.0
.16	1.0	57.3	3,430.0	206,000	1,018.6	.636	.318
.00279	.017453	1.0	60.0	3,600	17.778	.0111	.00556
.0000463	.000289	.0167	1.0	60	.297	.000185	.0000925
.00000078	.0000049	.00028	.0167	1	.00495	.0000003	.00000016
.000157	.000982	.05625	3.375	202	1.0	.000625	.000312
.25	1.535	90.0	5,400.0	324,000	1,600.0	1.0	.5
.50	3.07	180.0	10,800.0	648,000	3,200.0	2.0	1.0

e. Power.

Kilogram-meters per sec	Foot-pounds per sec	Horsepower		Poncelets	Kilowatts	Watts	Thermal units per sec	
		U. S.	Metric				Btu's	Kilocalories
1.0	7.233	0.01315	0.01333	0.01	0.00981	9.80597	0.009296	0.002342
.13826	1.0	.001818	.001843	.001383	.001356	1.35573	.001285	.0003237
76.0404	550.0	1.0	1.01387	.7604	.74565	745.65	.70865	.17812

75.0	542.475	.98632	1.0	.75	.73545	735.448	.69718	.17569
100.0	723.3	1.31509	1.33333	1.0	.9806	980.597	.92957	.23425
101.979	737.612	1.3411	1.35972	1.0198	1.0	1,000.0	.94796	.23888
.10198	.73761	.001341	.001360	.00102	.001	1.0	.000948	.0002389
107.577	778.104	1.41474	1.43436	1.07577	1.0549	1,054.9	1.0	.252
426.9	3,087.77	5.61412	5.692	4.269	4.1862	4,186.17	3.9683	1.0

f. Weight.

Kilograms (kg)	Grains (gr)	Ounces		Pounds		Tons		
		Troy	Avoirdupois (avdp)	Troy	Avoirdupois (avdp)	Short (2,000 lb)	Long (2,240 lb)	Metric (1,000 kg)
1.0	15,432.4	32.1507	35.274	2.67923	2.20462	0.001102	0.0009842	0.001
.0000648	1.0	.002083	.0002286	.0001736	.0001429	.00000007	.00000006	.00000006
.0311	480.0	1.0	1.09714	.08333	.06857	.00003429	.00003061	.0000311
.02385	437.5	.91146	1.0	.07595	.0625	.00003125	.0000279	.00002835
.37324	5,760.0	12.0	13.1657	1.0	.82286	.0004114	.0003674	.0003732
.45359	7,000.0	14.5833	16.0	1.21528	1.0	.0005	.0004464	.004536
907.185	14,000,000.0	29,166.7	32,000.0	2,430.56	2,000.0	1.0	.89286	.90719
1,016.05	15,680,000.0	32,666.7	35,840.0	2,722.22	2,240.0	1.12	1.0	1.01605
1,000.0	15,432,356.0	32,150.7	35,274.0	2,679.23	2,204.62	1.10232	.98421	1.0

Miscellaneous weight relationships:

Avoirdupois

1 ounce = 16 drams
1 stone = 14 pounds
1 dram = 1.772 grams

Troy

1 carat = 0.2 gram = 3.086 grains
1 pennyweight = 1.555 grams = 24 grains
1 ounce = 20 pennyweights

Apothecaries

1 scruple = 20 grains
1 ounce = 8 drams
1 dram = 3 scruples

Weight system comparisons:

	<i>Grain</i>	<i>Ounce</i>	<i>Pound</i>
Avoirdupois	1	437.5 grains	7,000 grains
Troy	1	480 grains	5,760 grains
Apothecaries	1	480 grains	5,760 grains

g. Speed.

Meters per second	Meters per minute	Feet per second	Feet per minute	Miles per hour	Knots per hour	Kilo- meters per hour
1.0	60.0	3.28083	196.8	2.23693	1.94254	3.6
.0167	1.0	.055	3.3	.0376	.0324	.06
.30480	18.2	1.0	60.0	.68182	.59209	1.09728
.00505	.303	.0167	1.0	.0113	.0097	.0182
.44704	26.9	1.4667	88.0	1.0	.86839	1.60935
.51479	30.9	1.68894	101.0	1.15155	1.0	1.85325
.27778	16.7	.91134	54.7	.62137	.53959	1.0

h. Temperature. The table below shows re-

°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.
-66	-54.4	-40	-40.0	-14	-25.6	12	-11.1	38	3.3	64	17.8	90	32.2
-65	-53.9	-39	-39.4	-13	-25.0	13	-10.6	39	3.9	65	18.3	91	32.8
-64	-53.3	-38	-38.9	-12	-24.4	14	-10.0	40	4.4	66	18.9	92	33.3
-63	-52.7	-37	-38.3	-11	-23.9	15	-9.4	41	5.0	67	19.4	93	33.9
-62	-52.2	-36	-37.8	-10	-23.3	16	-8.9	42	5.6	68	20.0	94	34.4
-61	-51.6	-35	-37.2	-9	-22.8	17	-8.3	43	6.1	69	20.6	95	35.0
-60	-51.1	-34	-36.7	-8	-22.2	18	-7.8	44	6.7	70	21.1	96	35.6
-59	-50.6	-33	-36.1	-7	-21.7	19	-7.2	45	7.2	71	21.7	97	36.1
-58	-50.0	-32	-35.6	-6	-21.1	20	-6.7	46	7.8	72	22.2	98	36.7
-57	-49.4	-31	-35.0	-5	-20.6	21	-6.1	47	8.3	73	22.8	99	37.2
-56	-48.9	-30	-34.4	-4	-20.0	22	-5.6	48	8.9	74	23.3	100	37.8
-55	-48.3	-29	-33.9	-3	-19.5	23	-5.0	49	9.4	75	23.9	101	38.3
-54	-47.8	-28	-33.3	-2	-18.9	24	-4.4	50	10.0	76	24.4	102	38.9
-53	-47.2	-27	-32.8	-1	-18.3	25	-3.9	51	10.6	77	25.0	103	39.4
-52	-46.6	-26	-32.2	0	-17.8	26	-3.3	52	11.1	78	25.6	104	40.0
-51	-46.1	-25	-31.7	1	-17.2	27	-2.8	53	11.7	79	26.1	105	40.6
-50	-45.6	-24	-31.1	2	-16.7	28	-2.2	54	12.2	80	26.7	106	41.1
-49	-45.0	-23	-30.6	3	-16.1	29	-1.7	55	12.8	81	27.2	107	41.6
-48	-44.4	-22	-30.0	4	-15.6	30	-1.1	56	13.3	82	27.8	108	42.2
-47	-43.9	-21	-29.4	5	-15.0	31	-0.6	57	13.9	83	28.3	109	42.7
-46	-43.3	-20	-28.9	6	-14.4	32	0	58	14.4	84	28.9	110	43.3
-45	-42.8	-19	-28.3	7	-13.9	33	0.6	59	15.0	85	29.4	111	43.9
-44	-42.2	-18	-27.8	8	-13.3	34	1.1	60	15.6	86	30.0	112	44.4
-43	-41.6	-17	-27.2	9	-12.8	35	1.7	61	16.1	87	30.6	113	45.0
-42	-41.1	-16	-26.7	10	-12.2	36	2.2	62	16.7	88	31.1	114	45.6
-41	-40.6	-15	-26.1	11	-11.7	37	2.8	63	17.2	89	31.7	115	46.1

i. Simplified Conversion Factors for Quick Computation. The following are accurate to within 2 percent:

- Inches to centimeters—Multiply by 10 and divide by 4.
- Yards to meters —Multiply by 9 and divide by 10.
- Miles to kilometers —Multiply by 8 and divide by 5.
- Gallons to liters —Multiply by 4 and subtract 1/5 of the number of gallons.
- Pounds to kilograms —Multiply by 5 and divide by 11.

j. Pressure and Density Equivalents.

Pressure equivalents						Density equivalents				
Kilograms per sq cm (metric atmos- pheres)	Pounds per sq in.	Short tons per sq ft	Atmos- pheres	Columns of mercury (0° C. at sea level)		Grams per cu cm	Lbs per cu in.	Lbs per cu ft	Short tons per cu yd	Lbs per U.S. gal.
				Meters	Inches					
1	14.22	1.024	0.9678	0.7356	28.96	1	0.03613	62.43	0.8428	8.345
0.07031	1	0.072	0.06805	0.05171	2.036	27.68	1	1,728	23.33	231
0.9765	13.89	1	0.9451	0.7183	28.28	0.01602	0.000578	1	0.0135	0.1337
1.0332	14.70	1.058	1	0.76	29.92	1.187	0.04287	74.07	1	9.902
1.3595	19.34	1.392	1.316	1	39.37	0.1198	0.004329	7.481	0.1010	1
0.03453	0.4912	0.03536	0.03342	0.02540	1					

lationships between fahrenheit and centigrade readings for a temperature range covering most areas of the earth. Figure shown are close approximations that should cover the needs of the transportation planner or operator. To compute temperature conversions outside of the range shown, use one of the following formulas:

$$^{\circ}\text{C.} = \frac{5}{9} (^{\circ}\text{F.} - 32)$$

$$^{\circ}\text{F.} = \frac{9}{5} ^{\circ}\text{C.} + 32$$

k. Equivalents of Weight or Masses per Unit Lengths. The table shown below may be used for wires, pipes, rails, etc.

Grams per centimeter	Kilograms per kilometer	Kilograms per meter	Grains per inch	Pounds per foot	Pounds per yard	Pounds per mile
1.0	100.0	0.1	39.1983	0.067197	0.201591	354.80
0.01	1.0	0.001	0.391983	0.00067197	0.00201591	3.5480
10.0	1,000.0	1.0	391.983	0.67197	2.01591	3,548.00
0.025511	2.5511	0.0025511	1.0	0.00171429	0.00514286	9.0514
14.8816	1,488.16	1.48815	583.333	1.0	3.0	5,280.0
4.96054	496.054	0.49605	194.444	0.33333	1.0	1,760.0
0.0028185	0.28185	0.00028185	0.11048	0.00018939	0.00056818	1.0

l. Simplified Conversion Factors (Feet and Inches). The table below serves as a rapid means of converting inches to feet and inches and vice versa. Inches are shown in the extreme left column and in the spaces immediately above the three sets of double horizontal lines. In the body of the

table, feet and/or feet and inches are shown (a dash separates feet from inches). For example, to convert 197 inches to feet and inches, find the number below the figure 190 on the top horizontal line and opposite the figure 7. It is 16-5, which represents 16 feet and 5 inches.

INCHES																									
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250
0		1-8	2-6	3-4	4-2	5	5-10	6-8	7-6	8-4	9-2	10	10-10	11-8	12-6	13-4	14-2	15	15-10	16-8	17-6	18-4	19-2	20	20-10
1		1-9	2-7	3-5	4-3	5-1	5-11	6-9	7-7	8-5	9-3	10-1	10-11	11-9	12-7	13-5	14-3	15-1	15-11	16-9	17-7	18-5	19-3	20-1	20-11
2	1-0	1-10	2-8	3-6	4-4	5-2	6	6-10	7-8	8-6	9-4	10-2	11	11-10	12-8	13-6	14-4	15-2	16	16-10	17-8	18-6	19-4	20-2	21
3	1-1	1-11	2-9	3-7	4-5	5-3	6-1	6-11	7-9	8-7	9-5	10-3	11-1	11-11	12-9	13-7	14-5	15-3	16-1	16-11	17-9	18-7	19-5	20-3	21-1
4	1-2	2	2-10	3-8	4-6	5-4	6-2	7	7-10	8-8	9-6	10-4	11-2	12	12-10	13-8	14-6	15-4	16-2	17	17-10	18-8	19-6	20-4	21-2
5	1-3	2-1	2-11	3-9	4-7	5-5	6-3	7-1	7-11	8-9	9-7	10-5	11-3	12-1	12-11	13-9	14-7	15-5	16-3	17-1	17-11	18-9	19-7	20-5	21-3
6	1-4	2-2	3	3-10	4-8	5-6	6-4	7-2	8	8-10	9-8	10-6	11-4	12-2	13	13-10	14-8	15-6	16-4	17-2	18	18-10	19-8	20-6	21-4
7	1-5	2-3	3-1	3-11	4-9	5-7	6-5	7-3	8-1	8-11	9-9	10-7	11-5	12-3	13-1	13-11	14-9	15-7	16-5	17-3	18-1	18-11	19-9	20-7	21-5
8	1-6	2-4	3-2	4	4-10	5-8	6-6	7-4	8-2	9	9-10	10-8	11-6	12-4	13-2	14	14-10	15-8	16-6	17-4	18-2	19	19-10	20-8	21-6
9	1-7	2-5	3-3	4-1	4-11	5-9	6-7	7-5	8-3	9-1	9-11	10-9	11-7	12-5	13-3	14-1	14-11	15-9	16-7	17-5	18-3	19-1	19-11	20-9	21-7
	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
0	21-8	22-6	23-4	24-2	25	25-10	26-8	27-6	28-4	29-2	30	30-10	31-8	32-6	33-4	34-2	35	35-10	36-8	37-6	38-4	39-2	40	40-10	41-8
1	21-9	22-7	23-5	24-3	25-1	25-11	26-9	27-7	28-5	29-3	30-1	30-11	31-9	32-7	33-5	34-3	35-1	35-11	36-9	37-7	38-5	39-3	40-1	40-11	41-9
2	21-10	22-8	23-6	24-4	25-2	26	26-10	27-8	28-6	29-4	30-2	31	31-10	32-8	33-6	34-4	35-2	36	36-10	37-8	38-6	39-4	40-2	41	41-10
3	21-11	22-9	23-7	24-5	25-3	26-1	26-11	27-9	28-7	29-5	30-3	31-1	31-11	32-9	33-7	34-5	35-3	36-1	36-11	37-9	38-7	39-5	40-3	41-1	41-11
4	22	22-10	23-8	24-6	25-4	26-2	27	27-10	28-8	29-6	30-4	31-2	32	32-10	33-8	34-6	35-4	36-2	37	37-10	38-8	39-6	40-4	41-2	42
5	22-1	22-11	23-9	24-7	25-5	26-3	27-1	27-11	28-9	29-7	30-5	31-3	32-1	32-11	33-9	34-7	35-5	36-3	37-1	37-11	38-9	39-7	40-5	41-3	42-1
6	22-2	23	23-10	24-8	25-6	26-4	27-2	28	28-10	29-8	30-6	31-4	32-2	33	33-10	34-8	35-6	36-4	37-2	38	38-10	39-8	40-6	41-4	42-2
7	22-3	23-1	23-11	24-9	25-7	26-5	27-3	28-1	28-11	29-9	30-7	31-5	32-3	33-1	33-11	34-9	35-7	36-5	37-3	38-1	38-11	39-9	40-7	41-5	42-3
8	22-4	23-2	24	24-10	25-8	26-6	27-4	28-2	29	29-10	30-8	31-6	32-4	33-2	34	34-10	35-8	36-6	37-4	38-2	39	39-10	40-8	41-6	42-4
9	22-5	23-3	24-1	24-11	25-9	26-7	27-5	28-3	29-1	29-11	30-9	31-7	32-5	33-3	34-1	34-11	35-9	36-7	37-5	38-3	39-1	39-11	40-9	41-7	42-5

	510	520	530	540	550	560	570	580	590	600	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750
0	42-6	43-4	44-2	45	45-10	46-8	47-6	48-4	49-2	50	50-10	51-8	52-6	53-4	54-2	55	55-10	56-8	57-6	58-4	59-2	60	60-10	61-8	62-6
1	42-7	43-5	44-3	45-1	45-11	46-9	47-7	48-5	49-3	50-1	50-11	51-9	52-7	53-5	54-3	55-1	55-11	56-9	57-7	58-5	59-3	60-1	60-11	61-9	62-7
2	42-8	43-6	44-4	45-2	46	46-10	47-8	48-6	49-4	50-2	51	51-10	52-8	53-6	54-4	55-2	56	56-10	57-8	58-6	59-4	60-2	61	61-10	62-8
3	42-9	43-7	44-5	45-3	46-1	46-11	47-9	48-7	49-5	50-3	51-1	51-11	52-9	53-7	54-5	55-3	56-1	56-11	57-9	58-7	59-5	60-3	61-1	61-11	62-9
4	42-10	43-8	44-6	45-4	46-2	47	47-10	48-8	49-6	50-4	51-2	52	52-10	53-8	54-6	55-4	56-2	57	57-10	58-8	59-6	60-4	61-2	62	62-10
5	42-11	43-9	44-7	45-5	46-3	47-1	47-11	48-9	49-7	50-5	51-3	52-1	52-11	53-9	54-7	55-5	56-3	57-1	57-11	58-9	59-7	60-5	61-3	62-1	62-11
6	43	43-10	44-8	45-6	46-4	47-2	48	48-10	49-8	50-6	51-4	52-2	53	53-10	54-8	55-6	56-4	57-2	58	58-10	59-8	60-6	61-4	62-2	63
7	43-1	43-11	44-9	45-7	46-5	47-3	48-1	48-11	49-9	50-7	51-5	52-3	53-1	53-11	54-9	55-7	56-5	57-3	58-1	58-11	59-9	60-7	61-5	62-3	63-1
8	43-2	44	44-10	45-8	46-6	47-4	48-2	49	49-10	50-8	51-6	52-4	53-2	54	54-10	55-8	56-6	57-4	58-2	59	59-10	60-8	61-6	62-4	63-2
9	43-3	44-1	44-11	45-9	46-7	47-5	48-3	49-1	49-11	50-9	51-7	52-5	53-3	54-1	54-11	55-9	56-7	57-5	58-3	59-1	59-11	60-9	61-7	62-5	63-3

7.48 Conversion of Fuel and Lubricants From Gallons to Tons

The scale in figure 7.13 is approximate and should be used only for rapid computation. For this reason, weights given per unit of volume are slightly heavier than average.

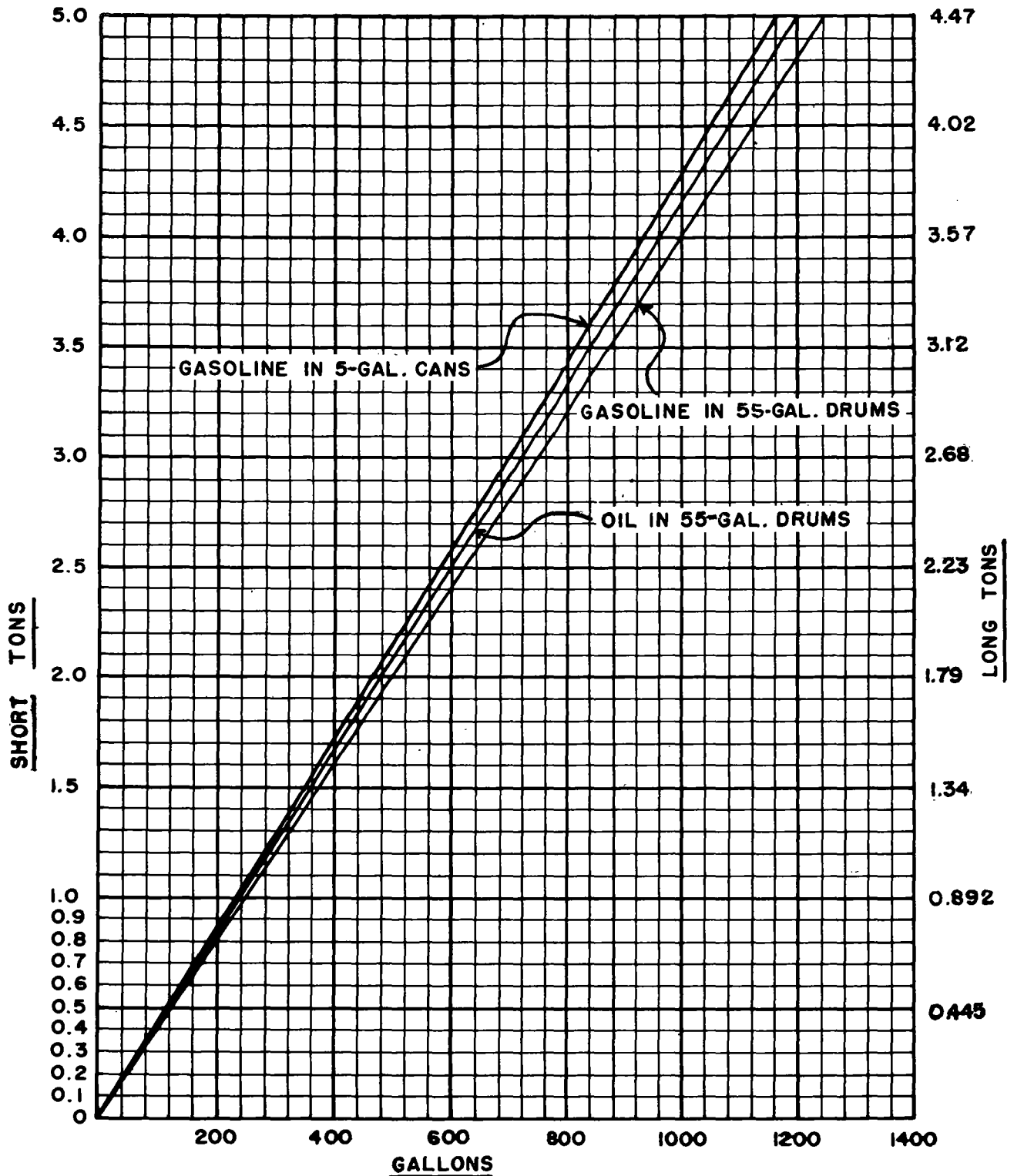


Figure 7.13. Scale for converting gallons of fuel and lubricants to tons.

7.49 Petroleum Conversion Factors

(Conversion factors give averages, not exact figures.)

Multiply	By	To obtain
Gallons, gasoline.....	0.0027	Long tons.
Gallons, gasoline.....	.0026	Metric tons.
Gallons, gasoline.....	6.103	Pounds.
Gallons, gasoline.....	.0031	Short tons.
Gallons, oil.....	7.434	Pounds.
Long tons.....	367.21	Gallons, gasoline.
Measurement tons.....	1.086	Short tons, gasoline.
Measurement tons.....	1.4285	Short tons, gasoline in drums.
Measurement tons.....	1.0	Short tons, grease.
Measurement tons.....	1.11	Short tons, oil.
Measurement tons.....	1.2048	Short tons, oil in drums.
Metric tons.....	373.10	Gallons, gasoline.
Pounds.....	.1639	Gallons, gasoline.
Pounds.....	.1345	Gallons, oil.
Short tons.....	327.8	Gallons, gasoline.
Short tons, gasoline.....	.9195	Measurement tons.
Short tons, gasoline in drums.....	.7	Measurement tons.
Short tons, grease.....	1.0	Measurement tons.
Short tons, oil.....	.90	Measurement tons.
Short tons, oil in drums.....	.83	Measurement tons.

7.50 Map-Distance Conversion

a. Table.

Map distance	Ground distance	Representative fraction (RF)							
		1 25,000	1 50,000	1 75,000	1 100,000	1 200,000	1 250,000	1 500,000	1 1,000,000
One inch.....	Inches.....	25,000	50,000	75,000	100,000	200,000	250,000	500,000	1,000,000
	Feet.....	2,083	4,167	6,250	8,333	16,667	20,833	41,667	83,333
	Yards.....	694	1,389	2,083	2,778	5,555	6,944	13,888	27,776
	Kilometers.....	.635	1.27	1.91	2.54	5.08	6.35	12.7	25.4
	Miles.....	.393	.790	1.19	1.58	3.15	3.94	7.9	15.76
	Meters.....	635	1,270	1,910	2,540	5,080	6,350	12,700	25,400
One centimeter..	Inches.....	9,843	19,685	29,528	39,370	78,740	98,425	196,850	393,700
	Feet.....	820	1,640	2,460	3,281	6,562	8,202	16,404	32,808
	Yards.....	273	547	820	1,094	2,187	2,734	5,468	10,936
	Kilometers.....	.250	.500	.750	1.0	2.0	2.5	5.0	10.0
	Miles.....	.154	.31	.465	.62	1.24	1.55	3.1	6.2
	Meters.....	250	500	750	1,000	2,000	2,500	5,000	10,000

b. Examples of use.

- (1) A map distance of 1 inch is equivalent to a ground distance of 4,167 feet on a map with RF of 1/50,000.
- (2) A map distance of 1 inch is equivalent to a ground distance of 3.15 miles on a map with RF of 1/200,000.
- (3) A map distance of 1 centimeter is equivalent to a ground distance of 273 yards on a map with RF of 1/25,000.

7.51 Speed Conversion Table, Approximate

Miles per hour	Knots	Feet per second	Kilometers per hour	Meters per second
1	0.8684	1.4667	1.6093	0.447
2	1.74	2.94	3.23	.897
3	2.59	4.41	4.83	1.34
4	3.46	5.90	6.45	1.78
5	4.34	7.33	8.05	2.23
6	5.20	8.80	9.65	2.68
7	6.07	10.30	11.30	3.13
8	6.95	11.80	12.90	3.58
9	7.81	13.22	14.50	4.03
10	8.68	14.67	16.09	4.47
11	9.55	16.20	17.70	4.92
12	10.40	17.62	19.30	5.37
13	11.23	19.10	20.90	5.82
14	12.10	20.60	22.60	6.27
15	13.00	22.10	24.20	6.71
16	13.90	23.50	25.80	7.16
17	14.75	25.00	27.40	7.63
18	15.60	26.40	28.90	8.05
19	16.45	28.00	30.60	8.50
20	17.40	29.30	32.20	8.95
21	18.20	30.90	33.80	9.39
22	19.10	32.30	35.40	9.85
23	20.00	33.80	37.10	10.30
24	20.80	35.30	38.60	10.75
25	21.70	36.70	40.30	11.15
26	22.50	38.20	41.90	11.60
27	23.40	39.70	43.50	12.10
28	24.30	41.20	45.10	12.50
29	25.20	42.60	46.70	13.00
30	26.00	44.20	48.30	13.40
31	26.90	45.60	50.00	13.90
32	27.80	47.00	51.50	14.30
33	28.60	48.50	53.00	14.73
34	29.50	50.00	54.55	15.20
35	30.40	51.50	56.50	15.65
36	31.20	53.00	58.00	16.10
37	32.00	54.50	59.70	16.50
38	32.90	56.00	61.40	17.00
39	33.80	57.50	62.80	17.40
40	34.60	58.80	64.50	17.83
41	35.60	60.50	66.00	18.38
42	36.40	61.90	67.70	18.80
43	37.30	63.40	69.20	19.20
44	38.20	64.80	71.00	19.70
45	38.90	66.50	72.50	20.20
46	40.00	67.50	74.00	20.60
47	40.70	69.10	75.90	21.00
48	41.50	70.50	77.50	21.40
49	42.40	72.00	79.00	21.80
50	43.50	73.80	80.50	22.30
51	44.10	74.90	82.00	22.80
52	45.10	76.50	83.60	23.20
53	46.00	78.00	85.70	23.70
54	46.70	79.50	87.00	24.20
55	47.50	80.90	88.70	24.60
56	48.50	82.20	90.00	25.00
57	49.50	83.90	91.90	25.50
58	50.10	85.00	93.40	25.90
59	51.00	86.80	95.00	26.40

Miles per hour	Knots	Feet per second	Kilometers per hour	Meters per second
60	52.00	88.10	96.70	26.80
61	53.00	89.60	98.00	27.20
62	53.70	91.10	99.80	27.70
63	54.60	92.90	101.70	28.20
64	55.60	94.20	103.00	28.60
65	56.20	95.30	104.50	29.10
66	57.20	97.00	106.00	29.50
67	58.00	98.20	108.00	30.00
68	58.90	100.00	109.50	30.40
69	59.80	101.80	111.00	30.80
70	60.70	103.00	113.00	31.30
71	61.60	104.00	114.00	31.70
72	62.50	106.00	116.00	32.20
73	63.30	107.30	117.30	32.60
74	64.20	109.00	119.00	33.10
75	65.00	110.00	121.00	33.60

7.52 Conversion of Foreign Measures to United States Measures

Country	Weight or measure	U. S. equivalent
Argentina	Arroba	25.32 lb
	Baril	20.077 gal.
	Cuadra	4.2 acres
	Frasco (liq)	2.509 qt (liq)
	Last	58.4 bu
	Libra	1.013 lb
	Pie	0.947 ft
	Quintal	101.28 lb
Australia	Vara	34.094 in.
	Same as United Kingdom	
Austria	Joch	1.422 acres
	Klafter	2.074 yd
Belgium	Last	85.134 bu
Bolivia	Marc	0.507 lb
Borneo	Picul	135.64 lb
Brazil	Arroba	32.379 lb
	Quintal	120.54 lb
Canada	Same as United Kingdom	
Celebes	Picul	135.64 lb
Central America	Centore	4.263 gal.
	Fanega	1.574 bu
	Libra	1.014 lb
	Manzana	1.727 acres
	Vara	32.913 in.
Chile	Fanega	2.753 bu
	Libra	1.014 lb
	Quintal	101.41 lb
	Vara	32.913 in.
China	Catty	1.333 lb
	Ch'ih	12.6 in.
	Li	1,890 ft
	Picul	133.333 lb
	Tael Kuping	575.64 grains (troy)
	Chun	1.26 in.

Country	Weight or measure	U. S. equivalent	
	Chang-----	10.49 ft	
	Tsun-----	1.409 in.	
	Feng-----	0.1259 in.	
	Hou-----	0.0013 in.	
	Shih tan-----	110.23 lb	
	Shi li-----	1,889.28 ft	
Cuba-----	Libra-----	1.014 lb	
	Vara-----	33.386 in.	
Denmark-----	Centner-----	110.23 lb	
	Mil-----	4.68 miles	
	Mil (geographic)-----	4.61 miles	
	Pund-----	1.102 lb	
	Tende (grain)-----	3.948 bu	
	Tondeland-----	1.36 acres	
	Viertel-----	1.701 gal.	
Dutch Guiana-----	Livre-----	1.089 lb	
Ecuador-----	Fanega-----	1.574 bu	
Egypt-----	Ardeb-----	5.619 bu	
	Cantar-----	99.05 lb	
	Feddan-----	1.04 acres	
	Oke-----	2.805 lb	
	Pic-----	22.83 in.	
France-----	Tonne-----	2,204.62 lb	
Germany-----	Klafter-----	2.074 yd	
	Last-----	4,409.2 lb	
	Bremer-----	Centner-----	127.5 lb
	Brunswick-----	Centner-----	117.5 lb
	Prussia-----	Centner-----	113.34 lb
Greece-----	Drachma (new)-----	1 metric gr	
	Livre-----	1.1 lb	
	Mina (old)-----	2.202 lb	
	Oke-----	2.82 lb	
Guatemala-----	Fanega-----	1.53 bu	
	Libra-----	1.014 lb	
	Vara-----	32.909 in.	
Honduras-----	Milla-----	1.149 miles	
	Vara-----	32.953 in.	
Hong Kong-----	Catty-----	1.333 lb	
	Picul-----	133.333 lb	
Hungary-----	Joch-----	1.067 acres	
India:			
Bombay-----	Candy-----	569 lb	
Madras-----	Candy-----	500 lb	
	Maund (standard)-----	82.285 lb	
	Ser-----	2.204 lb	
	Chittak-----	900 grains	
	Seer (factory)-----	1.866 lb	
	Seer (standard)-----	2.057 lb	
	Tola-----	0.4114 oz	
Indonesia-----	Buow-----	1.7536 acres	
	Katti-----	1.36 lb	
	Paal-----	561.16 acres	
Java-----	Paal-----	1,506 meters	
Sumatra-----	Paal, square-----	1,852 meters	
	Picul-----	136.16 lb	
Iran-----	Jarib-----	2.471 acres	
Israel-----	Rottle-----	6.35 lb	
Japan-----	Bu-----	0.12 in.	
	Catty-----	1.32 lb	
	Cho-----	2.451 acres	
	Ken-----	5.97 ft	

Country	Weight or measure	U. S. equivalent
	Koku	5.119 bu
	Kwamme	8.267 lb
	Se	0.024 acres
	Shaku	11.93 in.
	Sho (liq)	1.91 qt (liq)
	Sun	1.193 in.
	Tan	0.25 acres
	To	2.05 pk
	Tsubo	35.58 sq ft
	Go	0.19 qt
	Jo	3.31 yd
	Kin	1.323 lb
	Koku	47.65 gal.
	Kwan	8.267 lb
	Momme	0.1333 oz
	Picul	132.3 lb
	Ri	2.44 miles
	Rin	0.012 in.
	Tsunbo	3.953 sq ft
	Chungbo	105.49 sq ft
Korea	Ja	1 ft
	Kwan	3.750 kg or 8.269 lb
	Ri	2.440 miles
	Sok	6.371 cu ft
Luxemburg	Fuder	264.18 gal.
Malacca	Catty	1.36 lb
Malaya	Bongkal	832.0 grains
Malta	Barrel (customs)	11.2 gal.
	Caffisco	5.4 gal.
	Cantaro	175 lb
	Salm	8.2 bu
Mexico	Baril	20.078 gal.
	Fanega	2.577 bu
	Frasco (liq)	2.5 qt (liq)
	Libra	1.014 lb
	Quintal	101.47 lb
	Vara	32.99 in.
Morocco	Artel	1.12 lb
	Cantar	112 lb
Nicaragua	Manzana	1.742 acres
	Milla	1.159 miles
	Vara	33.057 in.
Norway	Centner	110.23 lb
Paraguay	Arroba	25.32 lb
	Cuadra (lin)	94.7 yd
	Cuadra (sq)	1.85 acres
	League	4.633 acres
Peru	Libra	1.014 lb
	Quintal	101.43 lb
	Vara	31.913 in.
Philippines	Picul	139.44 lb
Poland	Garnice	1.056 gal.
	Vloka	41.5 acres
Portugal	Almude	4.422 gal.
	Li'ra	1.012 lb
Spain	Arroba	4.263 gal.
	Fanega	16 gal.
	Pie	0.914 ft
	Quintal	101.43 lb
Sweden	Centner	93.7 lb

Country	Weight or measure	U. S. equivalent	Multiply	By	To obtain
Sweden—Continued	Last	9,371.3 lb	Bushels (imperial)	1.032	Bushels (U.S.)
	Skalpund	0.937 lb	Bushels (U.S.)	.969	Bushels (imperial)
	Tunna	4.5 bu	Carat	3.086	Grains
	Tunnland	1.22 acres	Centimeters	.03281	Feet
Thailand	Catty, standard	1.333 lb	Centimeters	.3937	Inches
	Catty	2.667 lb	Cubic feet	.1782	Barrels
	Coyan	2,645.5 lb	Cubic feet	.02832	Cubic meters
Turkey	Cantar	124.45 lb	Cubic feet	.01	Tons (register)
	Oke	2.828 lb	Cubic feet per minute	.1247	Gallons per second
	Pik	27.9 in.			
U.S.S.R.	Arshin (lin)	28 in.	Cubic feet per second	646,315.0	Gallons per day
	Arshin (sq)	5.44 sq ft	Cubic meters	35.31	Cubic feet
	Berkovets	361.128 lb	Cubic meters	1.308	Cubic yards
	Chetvert	5.957 bu	Cubic yards	.7646	Cubic meters
	Dessiatine	2.699 acres	Days	1,440.0	Minutes
	Food	36.113 lb	Drams	1.772	Grams
	Funt	0.9 lb	Drams	.0625	Ounces
	Last	80.0 cu ft	Feet	30.48	Centimeters
	Sajene	7 ft	Feet of water	.8826	Inches of mercury
	Vedro	2.707 gal.	Feet of water	62.43	Pounds per square foot
	Verst	0.633 mile			
	Duim	1 in.	Feet of water	.4335	Pounds per square inch
	Foute	1 ft			
	Garnetz	2.98 qt	Gallons (imperial)	.1605	Cubic feet
	Milya	4.64 miles	Gallons (imperial)	1.201	Gallons (U.S.)
	Pfund	0.903 lb	Gallons (imperial)	4.543	Liters
	Pood or poud	36.11 lb	Gallons (U.S.)	.8327	Gallons (imperial)
	Pound	0.903 lb	Gallons (U.S.)	.0238	Barrels
	Zak	2.368 bu	Gallons per minute	.002228	Cubic feet per second
United Kingdom	Comb	4.128 bu			
	Gallon	1.2 gal.	Grams	15.43	Grains
	Last	82.56 bu	Grams	.001	Kilograms
	Load (timber)	50 cu ft	Grams	1,000.0	Milligrams
	Cwt (hundred wt)	112.0 lb	Grams	.03527	Ounces
	Quart (liq)	1.2 qt (liq)	Grams	.002205	Pounds
	Quart (dry)	1.3 qt (liq)	Hours	.04167	Days
	Quarter	8.256 bu	Hours	.005952	Weeks
	Sack (flour)	280 lb	Horsepower	42.40	Btu per minute
	Stone	14 lb	Horsepower	33,000.0	Foot-pounds per minute
	Wey	41.282 bu			
Uruguay	Cuadra	1.82 acres	Horsepower (boiler)	33,475.0	Btu per hour
	Fanega	3.888 bu	Horsepower-hours	2,545.0	Btu
	Libra	1.014 lb	Hundredweight	112.0	Pounds
Venezuela	Fanega	3.334 bu	Hundredweight	.508	Quintals
	Libra	1.014 lb	Inches	2.540	Centimeters
Yugoslavia	Wagon	10 metric tons	Inches	25.4001	Millimeters
Zanzibar	Frasila	35 lb	Inches	1,000.0	Mils
			Inches of mercury	.4912	Pounds per square inch
			Inches of water	.07355	Inches of mercury
			Inches of water	.03614	Pounds per square inch
			Kilograms	1,000.0	Grams
			Kiloliters	.159	Barrels
			Knots	1.0	Miles per hour (naut)
			Links (surveyors)	7.92	Inches
			Liters	.2642	Gallons (U.S.)
			Liters	1.76	Pint (imperial)
			Liters	2.1134	Pint (U.S.)

7.53 Miscellaneous Conversion Factors for U.S. and British Measures

Multiply	By	To obtain
Atmosphere	14.70	Pounds per square inch
Barrels	5.61	Cubic feet
Barrels	42.0	Gallons
Barrels	6.29	Kiloliters
Board feet	144.0	Cubic inches
Boiler horsepower	33,475.0	Btu per hour

Multiply	By	To obtain
Liters.....	1.057	Quart (liquid)
Meters.....	100.0	Centimeters
Millimeters.....	.0393	Inches
Mils.....	.001	Inches
Ounces.....	20	Pennyweights
Ounces.....	28.349	Grams
Ounces (fluid).....	1.805	Cubic inches
Pennyweight.....	24	Grains
Pounds.....	453.6	Grams
Pounds of water.....	.01603	Cubic feet
Pounds of water.....	.1198	Gallons (U.S.)
Pounds per square inch	2.307	Feet of water
Pounds per square inch	2.036	Inches of mercury
Quintals.....	1.97	Hundredweights
Quires.....	25.0	Sheets (of paper, etc.)

Multiply	By	To obtain
Reams.....	500.0	Sheets (of paper, etc.)
Short ton-miles.....	1.45968	Metric ton-kilo-meters
Square centimeters.....	.1550	Square inches
Square feet.....	929.0	Square centimeters
Square feet.....	144.0	Square inches
Square inches.....	6.452	Square centimeters
Stones.....	14.0	Pounds
Temp (° C.) plus 17.8	1.8	Temp (° F.)
Temp (° F.) minus 32	.5556	Temp (° C.)
Tons (measurement).....	40.0	Cubic feet
Tons (register).....	100.0	Cubic feet
Weeks.....	168.0	Hours

Section XII. STOWAGE FACTORS

7.54 Stowage Factors by Class and Service

a. Computation of Stowage Factor. The stowage factor is the number of cubic feet required to store 1 long ton (2,240 lb) of cargo. It may be computed by the following formula.

Stowage factor (cu ft)

$$= \frac{\text{cube of cargo (cu ft)} \times 2,240}{\text{weight in pounds}}$$

b. Weight-Volume Ratios. Weight-volume ratios are based on average cubage for each item. The measurement tonnage for any item can be found by multiplying its short ton weight by its conversion factor. Weight-volume ratios by classes of supply are given below.

Item ¹	Conversion factor (ST to MT)	Stowage factor
Class I: Rations.....	2.1	94
Class II:		
Chemical.....	2.3	103
Engineer..... ²	3.3	147
Medical (including Class I and IV).	2.5	112
Ordnance.....	1.8	80
Ordnance vehicle replacement.....	2.2	99
QM clothing and equipage.....	2.0	89
QM general supplies.....	2.8	125
Signal (including Class IV).....	3.8	170
Class III:		
Aviation fuel and lubricants (Class III A).	1.5	67
Fuel for temperate zone.....	2.0	89
Gas, oil, grease ² (less aviation).....	1.5	67

Item ¹	Conversion factor (ST to MT)	Stowage factor
Class IV:		
Aviation, supply and replacement Chemical (negligible).	4.0	179
Engineer construction material	1.5	67
Medical (included in Class II)		
Ordnance motor maintenance.....	1.0	45
QM sales items.....	1.7	76
Signal (included in Class II).....		
Transportation.....	2.4	108
Class V:		
Ammunition (less aviation).....	.9	40
Aviation ammunition.....	.9	40
Chemical ammunition.....	1.2	54

¹ Nongas conditions. Figures are based upon average conditions found in European and Pacific theaters; amounts will vary for polar regions.

² Consists of the following: 90-percent gasoline, 4-percent diesel fuel, 3-percent engine oil, 1-percent gear lube, 2-percent greases.

7.55 Average of Stowage Factors by Service

Supply service	Class of supply	Stowage factor
Chemical.....	All supplies less Class V.....	103
Engineer.....	All supplies.....	107
Medical.....	All supplies.....	112
Ordnance.....	All supplies less Class V.....	75
Quartermaster.....	All supplies.....	87
Signal.....	All supplies.....	170
Transportation.....	All supplies.....	108
Chemical.....	Class V.....	54
Ordnance.....	Class V.....	40

7.56 Average Densities of Common Materials and Specified Supply Items

Figures shown below will aid transportation planners and operators when making loading plans

for any mode of transportation. The information given is for specific items. When planning loads for the general classes of supply, see paragraphs 7.4, 7.32, 7.54, and 7.55.

a. Common Materials.

<i>Material</i>	<i>Weight (lb per cu ft)</i>
Acid:	
Muriatic, 40%.....	75
Nitric, 91%.....	94
Sulphuric, 87%.....	112
Alcohol, 100%:	
Ethyl.....	49
Methyl.....	50
Aluminum, cast-hammered.....	165
Apple timber.....	44
Asbestos.....	153
Ashes and cinders.....	40-45
Asphaltum.....	81
Ash timber:	
Black.....	34
White.....	42
Barley.....	39
Barytes.....	281
Basalt.....	184
Bauxite.....	159
Benzine.....	50
Birch timber.....	44
Bluestone.....	159
Borax.....	109
Boxwood, dry.....	60
Brass, cast-rolled.....	534
Bronze:	
Aluminum.....	481
Phosphor.....	554
Tin.....	509
Brick.....	100
Calcium.....	98
Carbon.....	134
Cedar timber, white or red.....	22
Cement:	
Mortar.....	135
Portland, loose, dry.....	94
Portland, set.....	183
Chalk.....	143
Chestnut timber.....	30
Cherry timber, wild red.....	27
Chloroform.....	95
Cinders:	
Blast furnace.....	57
Chemical plant.....	100
Clay:	
Damp, plastic.....	110
Dry.....	63
Marl (mineral).....	137
Wet.....	80
With gravel, dry.....	100
Coal:	
Anthracite.....	97
Bituminous.....	84
Charcoal, oak.....	33
Charcoal, pine.....	23

<i>Material</i>	<i>Weight (lb per cu ft)</i>
Coke.....	75
Lignite.....	78
Peat, turf, dry.....	47
Coal and coke, piled:	
Anthracite.....	47-58
Bituminous or lignite.....	40-54
Charcoal.....	10-14
Coke.....	23-32
Peat, turf.....	20-26
Cobalt.....	546
Concrete:	
Plain.....	140-150
Reinforced.....	150
Copper:	
Cast-rolled.....	556
Ore, pyrites.....	262
Cork.....	15
Cotton, compressed.....	45
Dolomite.....	181
Earth:	
Dry, loose.....	76
Dry, packed.....	95
Moist, loose.....	78
Moist, packed.....	96
Mud, flowing.....	108
Mud, packed.....	115
Ebony timber.....	78
Elm timber.....	35
Ether.....	46
Excelsior, baled.....	19
Feldspar, orthoclase.....	162
Fir timber:	
Balsam.....	25
Douglas.....	32
Flax.....	26
Flint.....	162
Garbage:	
Green.....	47
Tankage.....	27
Glass:	
Common.....	162
Crystal.....	184
Flint.....	247
Plate or crown.....	161
Gneiss.....	175
Gold:	
Cast-hammered.....	1,205
Coin (U.S.).....	1,073
Grain.....	48
Granite.....	165
Graphite.....	135
Gravel:	
Damp, loose.....	87
Dry, compacted.....	120
Greenstone, trap.....	187
Gumwood.....	57
Gypsum, alabaster.....	159
Hay or straw (bales).....	20
Hemlock timber.....	29
Hemp.....	90
Hickory timber.....	48
Hornblende.....	187

<i>Material</i>	<i>Weight (lb per cu ft)</i>	<i>Material</i>	<i>Weight (lb per cu ft)</i>
Ice.....	57	Mortar rubble:	
Indigo.....	63	Bluestone.....	147
Iridium.....	1,383	Granite, syenite, gneiss.....	153
Iron:		Limestone.....	147
Cast, pig.....	450	Marble.....	156
Ferrosilicon.....	437	Sandstone.....	137
Gray cast.....	442	Mercury.....	847
Ore:		Mica.....	183
Hematite.....	325	Monel metal, rolled.....	555
Hematite in bank.....	160-180	Mortar:	
Hematite loose.....	130-160	Lime, set.....	103
Limonite.....	237	Portland cement.....	135
Magnetite.....	315	Mud (river mud).....	90
Slag.....	172	Nickel.....	537
Spiegel-eisen.....	468	Oak timber:	
Wrought.....	485	Chestnut.....	46
Ivory.....	114	Live.....	54
Jute.....	30	Red or black.....	42
Kerosene.....	50	White.....	48
Lead:		Oats.....	26
Pure.....	710	Oils:	
Ore, galena.....	465	Mineral (lubricants).....	57
Leather.....	59	Vegetable.....	58
Lime, gypsum, loose.....	53-64	Paper:	
Limestone:		Books.....	58
Marble, quartz (solid).....	155	Manila.....	37
Marble, quartz (quarried, piled).....	95	News.....	38
Locust timber.....	45	Wrapping.....	10
Logwood, dry (average).....	57	Writing.....	64
Lumber, structural (average).....	42	Paraffin.....	56
Lye, soda (liquid).....	106	Petroleum, crude (average).....	54
Magnesite.....	187	Phosphate rock, apatite.....	200
Magnesium alloys.....	112	Phosphoric acid.....	97
Mahogany timber.....	44	Pine timber:	
Manganese:		Norway.....	34
Pure.....	475	Oregon.....	32
Ore, pyrolusite.....	259	Red.....	30
Manila.....	26	Southern.....	40
Maple timber:		White.....	27
Hard or sugar.....	43	Yellow:	
White.....	33	Long-leaf.....	44
Marble.....	170	Short-leaf.....	38
Masonry:		Pitch.....	69
Ashlar:		Plaster.....	53
Bluestone.....	153	Plaster of Paris.....	140
Granite, syenite, gneiss.....	159	Platinum, cast-hammered.....	1,330
Limestone.....	153	Poplar timber.....	27
Marble.....	162	Porphyry (mineral).....	172
Sandstone.....	143	Potassium.....	54
Brick:		Pumice, natural.....	40
Hard brick.....	128	Quartz, flint.....	165
Medium brick.....	112	Rags, baled:	
Sand-lime brick.....	112	Cotton.....	18
Soft brick.....	103	Linen.....	23
Concrete:		Woolen.....	20
Cement, cinder, etc.....	100	Redwood timber (California).....	26
Cement, slag, etc.....	130	Riprap:	
Cement, stone, sand.....	144	Limestone.....	80-85
Dry rubble:		Sandstone.....	90
Granite, syenite, gneiss.....	130	Shale.....	105
Limestone, marble.....	125	Rope.....	42
Sandstone, bluestone.....	110	Rosin.....	67

<i>Material</i>	<i>Weight (lb per cu ft)</i>	<i>Material</i>	<i>Weight (lb per cu ft)</i>
Rubber:		Walnut timber:	
Caoutchoue.....	59	Black.....	37
Goods.....	94	White.....	26
Pure.....	60	Water:	
Rye.....	45	Fresh.....	62
Salt, granulated, piled.....	48	Sea.....	64
Saltpeter.....	132	Wax, bees.....	61
Sand and gravel:		Wheat.....	48
Dry, loose.....	90-105	Willow timber.....	28
Dry, packed.....	105-120	Wood pulp.....	29
Wet.....	126	Wool, packed.....	82
Sandstone.....	143	Zinc:	
Sandstone, quarried, piled.....	82	Cast-rolled.....	440
Sawdust, dry.....	7	Ore, blende.....	253
Serpentine (mineral).....	171		
Shale:		<i>b. Subsistence.</i>	
Quarried, piled.....	92	(1) <i>Perishables and bulk staples.</i>	
Slate.....	172		
Silver:		<i>Material</i>	<i>Weight (lb per cu ft)</i>
Cast-hammered.....	656	Dairy Products:	
German.....	536	Butter.....	59.0
Sisal.....	24	Cheese.....	30.0
Slags:		Milk.....	65.0
Bank.....	67-72	Eggs.....	22.6
Bank screenings.....	98-117	Fruits:	
Machine.....	96	Fresh:	
Slag-sand.....	49-55	Apples.....	31.3
Snow:		Apricots.....	34.8
Compacted.....	20	Bananas.....	13.2
Fresh.....	8	Blackberries.....	21.5
Soapstone, talc.....	169	Cantaloupe.....	26.8
Soda ash.....	62	Casaba (Honey Dew).....	24.0
Soda, bicarbonate.....	86	Cherries.....	31.2
Sodium.....	61	Cranberries.....	24.6
Soil, wet.....	70	Figs.....	34.8
Spruce timber, white or red.....	28	Grapefruit.....	31.2
Starch.....	96	Grapes.....	28.9
Steel:		Lemons.....	33.2
Cold-drawn.....	489	Limes.....	36.9
Machine.....	487	Loganberries.....	21.1
Tool.....	481	Oranges.....	34.2
Stone riprap, wet.....	65	Peaches.....	23.3
Straw:		Pears.....	24.9
Baled.....	24	Pineapples.....	22.1
Loose.....	3	Plums.....	25.6
Sulphur.....	125	Raspberries.....	22.0
Sulphuric acid.....	115	Strawberries.....	22.0
Sycamore timber.....	37	Tangerines.....	35.5
Syenite (mineral).....	165	Frozen (average for all).....	36.2
Talc.....	170	Meats:	
Tallow.....	59	Beef:	
Tar, bituminous.....	75	Boneless.....	36.7
Teak timber:		Chuck.....	35.8
African.....	62	Corned.....	37.1
Indian.....	48	Dried, canned.....	39.8
Terra Cotta.....	122	Forequarter.....	27.0
Tin:		Hindquarter.....	19.1
Cast-hammered.....	459	Liver.....	45.7
Ore, cassiterite.....	418	Loin.....	18.1
Tobacco.....	28	Rounds.....	14.7
Tungsten.....	1,200	Ribs.....	23.3
Turpentine.....	54	Tenderloin.....	46.6

<i>Material</i>	<i>Weight (lb per cu ft)</i>	<i>Material</i>	<i>Weight (lb per cu ft)</i>
Lamb and Mutton:		Cabbage	24.5
Carcass.....	9.4	Carrots:	
Telescope.....	11.5	Bunched.....	18.9
Pork:		Topped.....	30.0
Bacon.....	36.9	Cauliflower.....	18.9
Boston butt.....	40.2	Celery.....	23.4
Ham.....	40.2	Corn, sweet.....	16.8
Ham, canned.....	37.4	Cucumbers.....	23.1
Loin.....	37.4	Eggplant.....	16.4
Pork shoulder.....	30.9	Lettuce.....	20.5
Salt pork.....	33.5	Onions:	
Spare rib.....	30.9	Dry.....	30.9
Poultry:		Green.....	16.8
Chicken, dressed:		Peas:	
Fryer.....	31.5	Green.....	14.4
Hen.....	40.2	Shelled.....	26.0
Chicken, cut-up.....	29.6	Peppers, sweet, green.....	17.6
Turkey.....	29.3	Potatoes:	
Sausage:		Irish.....	35.7
Bologna.....	32.5	Sweet.....	31.3
Frankfurter.....	35.2	Radishes.....	21.6
Liver.....	36.5	Spinach.....	14.8
Luncheon meat.....	37.3	Tomatoes.....	33.3
Pork, bulk.....	46.6	Turnips.....	30.9
Pork, link.....	35.2	Frozen (average for all).....	27.0
Salami.....	34.8	Water food:	
Veal:		Clams.....	28.2
Carcass and sides.....	13.7	Crab meat.....	27.1
Fabricated.....	14.6	Fish:	
Staples:		Drawn.....	32.8
Bread.....	18.0	Fillet.....	22.1
Cereals, bulk:		Smoked.....	24.6
Barley.....	39.0	Smoked fillet.....	51.6
Buckwheat.....	42.0	Oysters.....	26.5
Corn, rye.....	45.0	Shrimp.....	23.9
Oatmeal.....	38.0		
Oats.....	26.0		
Wheat.....	48.0		
Coffee.....	37.0		
Cornmeal.....	40.0		
Fats (average).....	58.0		
Flour:			
Loose.....	28.0		
Packed.....	47.0		
Honey.....	90.0		
Lard.....	60.0		
Molasses.....	38.0		
Rice.....	50.0		
Sugar:			
Brown.....	45.0		
White.....	42.0		
Tea.....	16.0		
Vegetables:			
Fresh:			
Asparagus.....	21.0		
Beans:			
Green or snap.....	14.7		
Lima.....	18.3		
Beets:			
Bunched.....	18.1		
Topped.....	30.9		
Broccoli.....	17.8		

(2) *Nonperishables in containers.*

<i>Material</i>	<i>Weight (lb per cu ft)</i>
Apples (No. 10 can).....	40.0
(No. 2 ½ can).....	37.9
(No. 2 can).....	38.0
Apple butter (No. 10 can).....	47.5
(No. 2 ½ can).....	45.0
(No. 2 can).....	44.5
Apples, dry (50-lb bag).....	33.3
Apricots (No. 10 can).....	43.8
(No. 2 ½ can).....	42.1
(No. 3 can).....	41.0
Bacon (12-lb slab).....	37.6
Beans (No. 10 can).....	43.8
(No. 2 ½ can).....	42.1
(No. 2 can).....	41.0
(No. 1 can).....	50.7
Beans, dry (100-lb sack).....	39.2
Beans, string (No. 10 can).....	41.6
(No. 2 ½ can).....	40.0
(No. 2 can).....	39.5
Beef, canned (6-lb can).....	62.0
Beef, roast (No. 10 can).....	42.5
Beets (No. 10 can).....	42.5
(No. 2 ½ can).....	40.0
(No. 2 can).....	41.0

<i>Material</i>	<i>Weight (lb per cu ft)</i>	<i>Material</i>	<i>Weight (lb per cu ft)</i>
Biscuits, Types C (2-lb pack).....	28.8	Salmon (1-lb container).....	47.7
Bouillon cubes (100 per pack).....	37.3	Salt (100-lb bag).....	39.2
Butter (5-lb pack).....	45.6	Sauerkraut (No. 10 can).....	40.9
Cabbage, dehy (5-lb pack).....	13.8	(No. 2½ can).....	38.9
Candy, hard (15-lb pack).....	33.1	(No. 2 can).....	39.5
Carrots (No. 10 can).....	42.5	Sausage (2-lb pack).....	44.3
(No. 2½ can).....	40.0	Sausage, Vienna (1 ½-lb pack).....	36.7
(No. 2 can).....	41.0	Soup, dehy (5-lb pack).....	28.6
Catsup (No. 10 can).....	45.0	Spaghetti (No. 10 can).....	43.2
(No. 2½ can).....	42.1	(No. 2½ can).....	41.1
(No. 2 can).....	41.0	(No. 2 can).....	41.0
Cereal, uncooked (22 oz).....	32.7	Spinach (No. 10 can).....	40.6
Cereal, individual.....	8.7	(No. 2½ can).....	38.9
Cheese, processed (6-lb pack).....	54.4	(No. 2 can).....	38.0
Chile con carne (No. 10 can).....	42.5	Stew, meat & veg (28-oz pack).....	40.7
(No. 2½ can).....	40.0	(30-oz pack).....	43.6
(No. 2 can).....	41.0	Sugar, granulated:	
Cocoa (5-lb pack).....	25.0	(10-lb pack).....	56.4
Coffee (16-lb bag).....	30.0	(100-lb pack).....	40.0
Corn (No. 10 can).....	43.2	Syrup (No. 10 can).....	52.2
(No. 2½ can).....	41.1	(1-lb container).....	62.1
(No. 2 can).....	41.0	Tea (5-lb box).....	13.0
Crackers, Graham (2-lb pack).....	30.0	Tomatoes (No. 10 can).....	41.9
Eggs, dehy (No. 10 can).....	25.0	(No. 2½ can).....	40.0
Figs (No. 10 can).....	45.0	(No. 2 can).....	39.5
(No. 2½ can).....	42.1	Tomato Juice (No. 10 can).....	41.6
(No. 2 can).....	42.5	(No. 2½ can).....	40.0
Flour (98-lb sack).....	36.1	(No. 2 can).....	39.5
Grapefruit (No. 10 can).....	41.6	Vegetables, mixed:	
(No. 2½ can).....	40.0	(No. 10 can).....	42.5
(No. 2 can).....	39.5	(No. 2 can).....	39.5
Hash, corned beef (5 ½-lb pack).....	33.1	Vinegar (1-gal. jar).....	67.0
Hash, meat & veg (No. 10 can).....	43.8		
Jam, assorted (No. 10 can).....	52.5		
(No. 2½ can).....	41.0		
(No. 2 can).....	47.0		
Lard (37-lb container).....	46.8		
Luncheon meat (6-lb pack).....	49.5		
Mackerel (14-oz can).....	26.7		
Milk, powdered (5-lb container).....	31.3		
Milk, evaporated (14½-oz pack).....	42.3		
Oats, rolled (48-oz pack).....	20.9		
Peaches and/or pears:			
(No. 10 can).....	43.8		
(No. 2½ can).....	41.1		
(No. 2 can).....	42.5		
Peanut butter (No. 10 can).....	43.8		
(No. 2½ can).....	41.1		
(No. 2 can).....	41.0		
Peas (No. 10 can).....	42.8		
(No. 2 can).....	41.0		
Pickles (1-gallon jar).....	48.5		
Pineapple, sliced:			
(No. 10 can).....	43.8		
(No. 2½ can).....	42.1		
(No. 2 can).....	41.0		
Pineapple juice (No. 10 can).....	41.7		
(No. 2 can).....	41.0		
Potatoes, dehy (No. 16-lb pack).....	33.0		
(10-lb pack).....	24.7		
Prunes, dry (25-lb bag).....	60.0		
(5-lb bag).....	44.4		

c. Clothing and Individual Equipment.

<i>Material</i>	<i>Weight (lb per cu ft)</i>
Axe, chopping.....	20
Bag, barracks.....	18
Bag, duffel.....	22
Bag, sleeping.....	17
Bar, mosquito.....	20
Belt, cartridge.....	20
Belt, pistol.....	22
Blanket, wool, OD.....	16
Boots, service, combat.....	18
Bunting, wool.....	21
Can, meat, aluminum.....	13
Canteen, aluminum.....	9
Cap, garrison, AG 44.....	18
Cap, service, wool.....	4
Carrier, pack.....	16
Case, canvas, dispatch.....	13
Coat, wool.....	14
Comforter, wool.....	7
Cover, canteen.....	11
Cup, canteen, aluminum.....	11
Drawers, cotton.....	21
Drawers, winter.....	18
Gloves, cotton.....	18
Gloves, leather.....	25
Gloves, wool.....	11
Handkerchief.....	25

Material	Weight (lb per cu ft)
Haversack.....	19
Helmet, steel, boxed.....	15
Holster (various types).....	15
Jacket, field.....	21
Jumper, dungaree.....	21
Laces, shoe.....	20
Liner, helmet.....	6
Mittens, inserts.....	16
Muffler, wool, OD.....	12
Necktie, mohair.....	15
Overcoat (w/wool insert).....	20
Pack, field, cargo.....	19
Pack, field, combat.....	18
Pants, sweat.....	20
Parka, field, cotton.....	23
Pin, tent.....	27
Pocket, cartridge.....	18
Pocket, magazine.....	25
Pole, tent, shelter.....	28
Pouch, first aid.....	15
Raincoat.....	30
Roll, bedding.....	32
Rope, manila.....	15
Scabbard, rifle.....	13
Shirt, cotton, khaki.....	20
Shirt, wool, OG.....	23
Shoes, low quarter.....	11
Shovel, intrenching.....	28
Socks, cotton.....	16
Socks, wool.....	14
Suit, HBT, protective.....	22
Sweater, wool.....	15
Tent, shelter half.....	23
Towel, bath.....	15
Trousers, cotton, khaki.....	22
Trousers, wool serge.....	23
Undershirt, cotton.....	18

d. Organizational Field Equipment.

Material	Weight (lb per cu ft)
Cans, galvanized:	
10-gal.....	17.6
24-gal.....	7.9
32-gal.....	8.4
Chair, folding, metal.....	12.8
Chair, folding, wood.....	11.0
Chest, record, fiber.....	9.0

Material	Weight (lb per cu ft)
Container, insulated.....	16.0
Container, water, 5-gal.....	11.6
Cot, canvas, folding.....	27.0
Cover, mattress.....	24.0
Desk, field, empty, fiber.....	9.0
*Duck, cotton.....	32.0
*Fly, tent, wall.....	30.0
Kit, barber.....	23.0
Locker, trunk.....	9.0
Mattress, cotton.....	4.0
*Paulin, canvas, small.....	21.0
*Paulin, canvas, large.....	43.0
Pillow, feather.....	8.0
Pillowcase.....	21.0
Pin, tent, 16".....	36.3
Pin, tent, 24".....	30.2
Pole, tent, ridge.....	27.0
Range, field.....	22.7
*Screen, latrine.....	27.1
Table, camp, folding.....	9.2
Table, mess.....	1.8
*Tent, command post.....	11.7
*Tent, GP, med.....	23.9
*Tent, storage.....	36.3
*Tent, wall, small.....	13.0
*Tent, wall, large.....	25.0

* Figures are average. Weight will vary with different types of material.

7.57 Rapid Computation of Weight of a Unit for Shipment

For planning purposes the weight in short tons of a unit is the sum of the combined weights of:

- TOE personnel and individual equipment, assuming average weight of 240 pounds per man.
- Major items of organizational equipment.
- Class I supplies for 3 days, assuming 6.6 pounds per ration per man per day.
- Class III supplies necessary to move unit 100 miles from destination point after arrival, if authorized in shipment.
- Basic load of class V.
- Added items that may be authorized by theater commander or CONUS commander.

Section XIII. MATHEMATICAL TABLES AND FORMULAS

7.58 Measurement of Surfaces and Solids

Figure	Formula
a. Area of:	
Circle.....	Square of the diameter times .7854, or square of the radius times 3.1416.
Sector of.....	Length of the arc times the radius divided by 2, or 3.1416 times square of

Figure	Formula
Segment of.....	radius times angle of the sector divided by 360.
	Area of the sector minus the area of the triangle formed by joining radii.
Cone.....	One-half of slant height times perimeter of base plus area of base.

Figure	Formula
Frustrum of	Slant height times sum of circumferences of bases divided by 2 plus sum of the areas of both bases.
Cube	Sum of areas of all the sides.
Cylinder	Area of 2 ends plus length times perimeter.
Ellipse	Long axis times short axis times .7854.
Parallelogram	Base times altitude.
Polygon	Perimeter times apothem divided by 2.
Prism	Area of 2 ends plus length times perimeter.
Pyramid	One-half of slant height times perimeter of base plus area of base.
Rectangle	Bases times altitude.
Sphere	Square of diameter times 3.1416.
Square	Base times altitude.
Straight-lined figure of 4 or more unequal sides.	Divide figure into triangles, find area of each triangle, and add areas.
Trapezoid	Altitude times sum of bases divided by 2.
Triangle	Base times altitude divided by 2.
b. Circumference of:	
Circle	Diameter times 3.1416.
Quadrilateral and Polygon.	Sum of all sides.
c. Volume of:	
Cone	Height times area of base divided by 3.
Frustrum of cone	Height times $\frac{(B + B' + \sqrt{B \times B'})}{3}$
Cube	Length times width times depth.
Cylinder	Area of the base times height.
Prism	Height times area of base.
Pyramid	Height times area of base divided by 3.
Frustrum of pyramid	Height times $\frac{(B + B' + \sqrt{B \times B'})}{3}$
Sphere	Cube of the diameter times .5236.
Tank, elliptical	Long axis times short axis times .7854 times length.
Irregular figure	Sum of volume of component parts. If possible, immerse figure in water and measure the displacement.

Note

Apothem—perpendicular from center of polygon to any side.

B and B'—area of upper and lower bases, respectively, of frustrum of cone or pyramid.

Frustrum—that part of a pyramid or cone included between the base and a section of the pyramid or cone parallel to the base.

Polygon—closed, straight-lined figure having more than 4 sides.

Quadrilateral—closed, straight-lined figure having 4 sides.

Regular polygon—closed, straight-lined figure having equal sides and equal angles.

Trapezoid—quadrilateral figure having one pair of parallel sides.

7.59 Functions of Numbers

Quantities in the table below are useful to the transportation planner when solving equations and formulas. Logarithms are particularly useful if a number is to be raised to a power above the cube or to a fractional power. The logarithm of a number is the exponent of the power to which a base must be raised to produce the number. For the purposes of this manual, the base can be considered to be 10. Therefore, the logarithm of a number to the base 10 is the power to which 10 must be raised to produce the number. For example—

$$\text{Log}_{10} 100 = 2.00000, \text{ since } 10^{2.00000} = 100$$

A logarithm has two parts—the characteristic (that part to the left of the decimal point), and a mantissa (that part to the right of the decimal point). The mantissa is always arranged to be positive. The characteristic is zero or positive and is one less than the number of digits to the left of the decimal point for one and numbers greater than one, and is negative and a minus one greater than the number of zeros to the right of the decimal point for numbers smaller than one. Thus the logarithm of 0.01 is $\bar{2}.00000$, which may also be expressed as $(1.00000 - 3)$, $(2.00000 - 4)$, $(3.00000 - 5)$, etc. In keeping the mantissa positive for numbers smaller than one, should there be a multiplier of the logarithm, the number to the right in the brackets should be the lowest possible number that will produce a whole number from the multiplier. For example, should the logarithm of a number equal $\frac{1}{3} \times 1.00000$, it should be expressed as $\frac{1}{3} \times (2.00000 - 3)$, which equals $0.66666 - 1$, or $\bar{1}.66666$. An example of the use of logarithms is presented by the problem of raising 44 to the 0.36 power.

$$\text{Let } x = (44)^{0.36}$$

$$\text{Then } \log x = 0.36 \times \log 44$$

$$= 0.36 \times 1.64345$$

$$= 0.59164$$

$$\text{and } x = \text{antilog of } 0.59164, \text{ or } 3.905$$

Number	Square	Square root	Cube	Cube root	Logarithm	Number	Square	Square root	Cube	Cube root	Logarithm
1	1	1.0000	1	1.000	0.00000	62	3844	7.8740	238328	3.958	1.79239
2	4	1.4142	8	1.260	.30103	63	3969	7.9373	250047	3.979	1.79934
3	9	1.7321	27	1.442	.47712	64	4096	8.0000	262144	4.000	1.80618
4	16	2.0000	64	1.587	.60206	65	4225	8.0623	274625	4.021	1.81291
5	25	2.2361	125	1.710	.69897	66	4356	8.1240	287496	4.041	1.81954
6	36	2.4495	216	1.817	.77815	67	4489	8.1854	300763	4.062	1.82607
7	49	2.6458	343	1.913	.84510	68	4624	8.2462	314432	4.082	1.83251
8	64	2.8284	512	2.000	.90309	69	4761	8.3066	328509	4.102	1.83885
9	81	3.0000	729	2.080	.95424	70	4900	8.3666	343000	4.121	1.84510
10	100	3.1623	1000	2.154	1.00000	71	5041	8.4261	357911	4.141	1.85126
11	121	3.3166	1331	2.224	1.04139	72	5184	8.4853	373248	4.160	1.85733
12	144	3.4641	1728	2.289	1.07918	73	5329	8.5540	389017	4.179	1.86332
13	169	3.6056	2197	2.351	1.11394	74	5476	8.6023	405224	4.198	1.86923
14	196	3.7417	2744	2.410	1.14613	75	5625	8.6603	421875	4.217	1.87506
15	225	3.8730	3375	2.466	1.17609	76	5776	8.7178	438976	4.236	1.88081
16	256	4.0000	4096	2.520	1.20412	77	5929	8.7750	456533	4.254	1.88649
17	289	4.1231	4913	2.571	1.23045	78	6084	8.8318	474552	4.273	1.89209
18	324	4.2426	5832	2.621	1.25527	79	6241	8.8882	493039	4.291	1.89763
19	361	4.3589	6859	2.668	1.27875	80	6400	8.9443	512000	4.309	1.90309
20	400	4.4721	8000	2.714	1.30103	81	6561	9.0000	531441	4.327	1.90849
21	441	4.5826	9261	2.759	1.32222	82	6724	9.0554	551368	4.344	1.91381
22	484	4.6904	10648	2.802	1.34242	83	6889	9.1104	571787	4.362	1.91908
23	529	4.7958	12167	2.844	1.36173	84	7056	9.1652	592704	4.380	1.92428
24	576	4.8990	13824	2.884	1.38021	85	7225	9.2195	614125	4.397	1.92942
25	625	5.0000	15625	2.924	1.39794	86	7396	9.2736	636056	4.414	1.93450
26	676	5.0990	17576	2.962	1.41497	87	7569	9.3274	658503	4.431	1.93952
27	729	5.1962	19683	3.000	1.43136	88	7744	9.3808	681472	4.448	1.94448
28	784	5.2915	21952	3.037	1.44716	89	7921	9.4340	704969	4.465	1.94939
29	841	5.3852	24389	3.072	1.46240	90	8100	9.4868	729000	4.481	1.95424
30	900	5.4772	27000	3.107	1.47712	91	8281	9.5394	753571	4.498	1.95904
31	961	5.5678	29791	3.141	1.49136	92	8464	9.5917	778688	4.514	1.96379
32	1024	5.6569	32768	3.175	1.50515	93	8649	9.6437	804357	4.531	1.96848
33	1089	5.7446	35937	3.208	1.51851	94	8836	9.6954	830584	4.547	1.97313
34	1156	5.8310	39304	3.240	1.53148	95	9025	9.7468	857375	4.563	1.97772
35	1225	5.9161	42875	3.271	1.54407	96	9216	9.7980	884736	4.579	1.98227
36	1296	6.0000	46656	3.302	1.55630	97	9409	9.8489	912673	4.595	1.98677
37	1369	6.0828	50653	3.332	1.56820	98	9604	9.8995	941192	4.610	1.99123
38	1444	6.1644	54872	3.362	1.57978	99	9801	9.9499	970299	4.626	1.99564
39	1521	6.2450	59319	3.391	1.59106	100	10000	10.0000	1000000	4.642	2.00000
40	1600	6.3246	64000	3.420	1.60216	0.1	0.01	0.3162	0.001	0.4641	1.00000
41	1681	6.4031	68921	3.448	1.61278	0.01	0.0001	0.1	0.000001	0.2154	2.00000
42	1764	6.4807	74088	3.476	1.62325	0.001	0.000001	0.03162	0.000000001	0.1	3.00000
43	1849	6.5574	79507	3.503	1.63347						
44	1936	6.6332	85184	3.530	1.64345						
45	2025	6.7082	91125	3.557	1.65321						
46	2116	6.7823	97336	3.583	1.66276						
47	2209	6.8557	103823	3.609	1.67210						
48	2304	6.9282	110592	3.634	1.68124						
49	2401	7.0000	117649	3.659	1.69020						
50	2500	7.0711	125000	3.684	1.69897						
51	2601	7.1414	132651	3.708	1.70757						
52	2704	7.2111	140608	3.733	1.71600						
53	2809	7.2801	148877	3.756	1.72428						
54	2916	7.3485	157464	3.780	1.73239						
55	3025	7.4162	166375	3.803	1.74036						
56	3136	7.4833	175616	3.826	1.74819						
57	3249	7.5498	185193	3.849	1.75587						
58	3364	7.6158	195112	3.871	1.76343						
59	3481	7.6811	205379	3.893	1.77085						
60	3600	7.7460	216000	3.915	1.77815						
61	3721	7.8102	226981	3.936	1.78533						

7:60 Decimal Equivalents

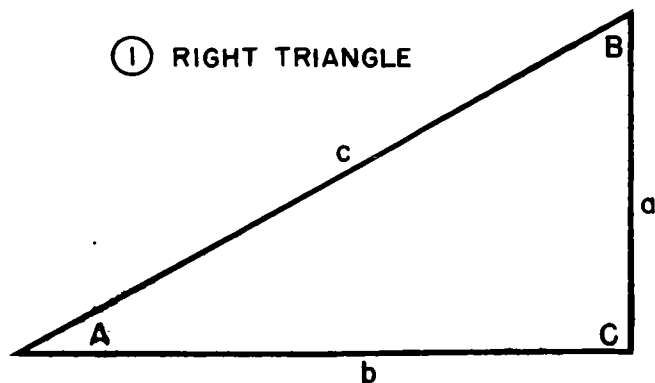
Inches						Inches	Millimeters
					$\frac{1}{64}$	0.015625	0.397
					$\frac{1}{32}$	.03125	.794
					$\frac{3}{64}$	.046875	1.191
					$\frac{1}{16}$	.0625	1.588
					$\frac{5}{64}$	.078125	1.984
					$\frac{1}{8}$	.09375	2.381
					$\frac{3}{16}$	.109375	2.778
					$\frac{1}{4}$	.125	3.175
					$\frac{5}{16}$	.140625	3.572
					$\frac{3}{8}$	.15625	3.969
					$\frac{7}{16}$	.171875	4.366
					$\frac{1}{2}$	.1875	4.763
					$\frac{5}{8}$	.203125	5.159

Inches				Inches	Millimeters
$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{32}$	.21875	5.556
			$\frac{15}{64}$	.234375	5.953
			$\frac{1}{4}$	.25	6.350
			$\frac{17}{64}$	.265625	6.747
		$\frac{3}{16}$	$\frac{9}{32}$	.28125	7.144
			$\frac{19}{64}$	.296875	7.541
			$\frac{5}{8}$	.3125	7.938
			$\frac{21}{64}$	.328125	8.334
	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{11}{16}$	.34375	8.731
			$\frac{23}{64}$	.359375	9.128
			$\frac{3}{4}$	.375	9.525
			$\frac{25}{64}$	.390625	9.922
		$\frac{7}{8}$	$\frac{13}{16}$	.40625	10.319
			$\frac{27}{64}$	.421875	10.716
			$\frac{1}{2}$	.4375	11.113
			$\frac{29}{64}$	.453125	11.509
$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{15}{16}$	.46875	11.906
			$\frac{31}{64}$	.484375	12.303
			$\frac{1}{2}$	.5	12.700
			$\frac{33}{64}$	.515625	13.097
		$\frac{1}{2}$	$\frac{17}{16}$	.53125	13.494
			$\frac{35}{64}$	.546875	13.891
			$\frac{3}{4}$	.5625	14.288
			$\frac{37}{64}$	.578125	14.684
			$\frac{19}{16}$	.59375	15.081

Inches				Inches	Millimeters
$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{29}{64}$	.609375	15.478
			$\frac{1}{4}$	.625	15.875
			$\frac{1}{4}$	.640625	16.272
			$\frac{21}{64}$	.65625	16.669
		$\frac{3}{16}$	$\frac{43}{64}$	.671875	17.066
			$\frac{11}{16}$	.6875	17.463
			$\frac{45}{64}$	.703125	17.859
			$\frac{23}{64}$	.71875	18.256
	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{47}{64}$	.734375	18.653
			$\frac{3}{4}$	.75	19.050
			$\frac{49}{64}$	.765625	19.447
			$\frac{25}{32}$	.78125	19.844
		$\frac{7}{8}$	$\frac{51}{64}$	.796875	20.241
			$\frac{13}{16}$	.8125	20.638
			$\frac{53}{64}$	.828125	21.034
			$\frac{27}{32}$	.84375	21.431
$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{55}{64}$	.859375	21.828
			$\frac{3}{4}$	.875	22.225
			$\frac{57}{64}$	.890625	22.622
			$\frac{29}{32}$	.90625	23.019
		$\frac{7}{8}$	$\frac{59}{64}$	.921875	23.416
			$\frac{15}{16}$	.9375	23.813
			$\frac{61}{64}$	.953125	24.209
			$\frac{31}{32}$	.96875	24.606
$\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{63}{64}$	.984375	25.003
			$\frac{1}{2}$	1.0	25.400

7.61 Trigonometric Solution of Triangles

① RIGHT TRIANGLE



$$\sin A = \frac{a}{c}$$

$$\cos A = \frac{b}{c}$$

$$\tan A = \frac{a}{b}$$

$$\cot A = \frac{b}{a}$$

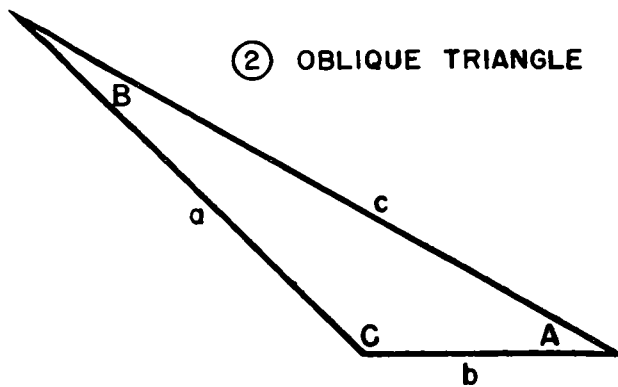
$$\sec A = \frac{c}{b}$$

$$\csc A = \frac{c}{a}$$

$$\text{Area} = \frac{ab}{2} = \frac{a}{2} \sqrt{c^2 - a^2} = \frac{a^2 \cot A}{2}$$

$$= \frac{b^2 \tan A}{2} = \frac{c^2 \sin 2A}{4}$$

② OBLIQUE TRIANGLE



$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$b^2 = a^2 + c^2 - 2ac \cos B$$

$$c^2 = a^2 + b^2 - 2ab \cos C$$

$$\text{Area} = \sqrt{s(s-a)(s-b)(s-c)}$$

Where

$$s = \frac{a + b + c}{2}$$

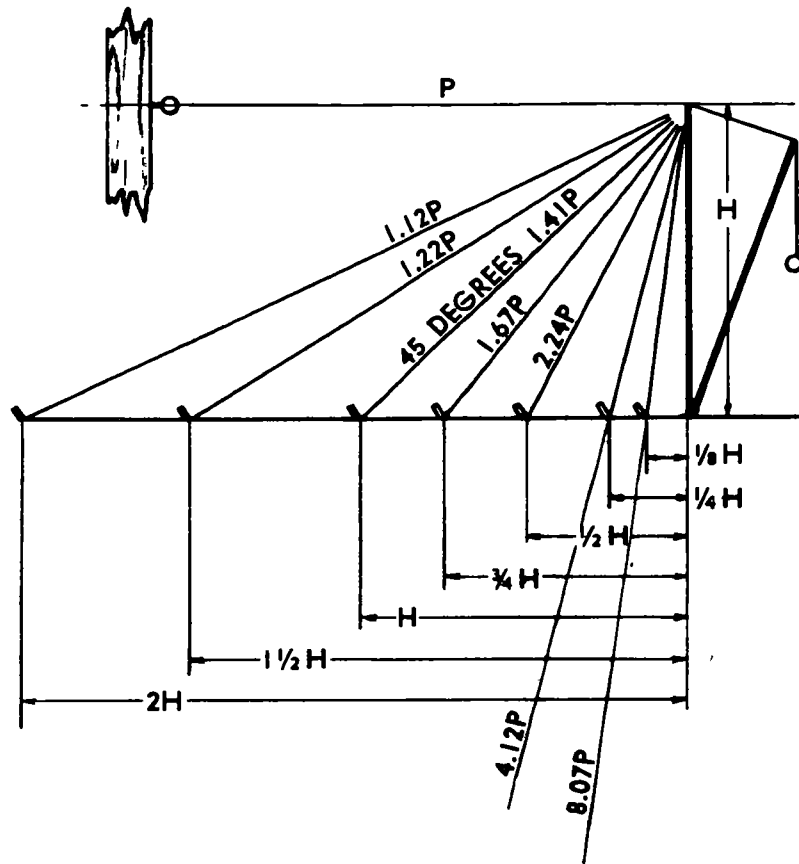
7.62 Natural Trigonometric Functions

Angle°	Sin	Cosec	Tan	Cotan	Sec	Coa	Angle°
0	0.000		0.000		1.000	1.000	90
1	.017	57.30	.017	57.29	1.000	1.000	89
2	.035	28.65	.035	28.64	1.001	.999	88
3	.052	19.11	.052	19.08	1.001	.999	87
4	.070	14.34	.070	14.30	1.002	.998	86
5	.087	11.47	.087	11.43	1.004	.996	85
6	.105	9.567	.105	9.514	1.006	.995	84
7	.122	8.206	.123	8.144	1.008	.993	83
8	.139	7.185	.141	7.115	1.010	.990	82
9	.156	6.392	.158	6.314	1.012	.988	81
10	.174	5.759	.176	5.671	1.015	.985	80
11	.191	5.241	.194	5.145	1.019	.982	79
12	.208	4.810	.213	4.705	1.022	.978	78
13	.225	4.445	.231	4.331	1.026	.974	77
14	.242	4.134	.249	4.011	1.031	.970	76
15	.259	3.864	.268	3.732	1.035	.966	75
16	.276	3.628	.287	3.487	1.040	.961	74
17	.292	3.420	.306	3.271	1.046	.956	73
18	.309	3.236	.325	3.078	1.051	.951	72
19	.326	3.072	.344	2.904	1.058	.946	71
20	.342	2.924	.364	2.747	1.064	.940	70
21	.358	2.790	.384	2.605	1.071	.934	69
22	.375	2.669	.404	2.475	1.079	.927	68
23	.391	2.559	.424	2.356	1.086	.921	67
24	.407	2.459	.445	2.246	1.095	.914	66
25	.423	2.366	.466	2.145	1.103	.906	65
26	.438	2.281	.488	2.050	1.113	.899	64
27	.454	2.203	.510	1.963	1.122	.891	63
28	.469	2.130	.532	1.881	1.133	.883	62
29	.485	2.063	.554	1.804	1.143	.875	61
30	.500	2.000	.577	1.732	1.155	.866	60
31	.515	1.942	.601	1.664	1.167	.857	59
32	.530	1.887	.625	1.600	1.179	.848	58

Angle°	Sin	Cosec	Tan	Cotan	Sec	Cos	Angle°
33	.545	1.836	.649	1.540	1.192	.839	57
34	.559	1.788	.675	1.483	1.206	.829	56
35	.574	1.743	.700	1.428	1.221	.819	55
36	.588	1.701	.727	1.376	1.236	.809	54
37	.602	1.662	.754	1.327	1.252	.799	53
38	.616	1.624	.781	1.280	1.269	.788	52
39	.629	1.589	.810	1.235	1.287	.777	51
40	.643	1.556	.839	1.192	1.305	.766	50
41	.656	1.542	.869	1.150	1.325	.755	49
42	.669	1.494	.900	1.111	1.346	.743	48
43	.682	1.466	.933	1.072	1.367	.731	47
44	.695	1.440	.966	1.036	1.390	.719	46
45	.707	1.414	1.000	1.000	1.414	.707	45
Angle°	Sin	Cosec	Tan	Cotan	Sec	Cos	Angle°

7.63 Computing Guy Stress

To compute the stress, or tension, that should be placed upon a guy, the horizontal and vertical distance relationships for upright poles, the weight of the load to be lifted, the weight of the pole, the horizontal distance from base of pole to the guy anchor, and the perpendicular distance from the base of pole to the guy must be considered. Relationships for computing stress are shown in figure 7.14; 1 illustrates tension or pull (P) for an upright pole when there are known relationships between height of the pole (H) and the ground distance from base of the pole to the guy anchor, and 2 shows how to compute guy stress when the pole is inclined.



TENSION

$$t = \frac{wd}{y}$$

WHERE

y = PERPENDICULAR DISTANCE FROM
BASE OF POLE TO REAR GUY
 w = WEIGHT OF LOAD + $\frac{1}{2}$ WEIGHT OF
POLE
 d = DISTANCE FROM GUY ANCHOR
TO BASE OF POLE

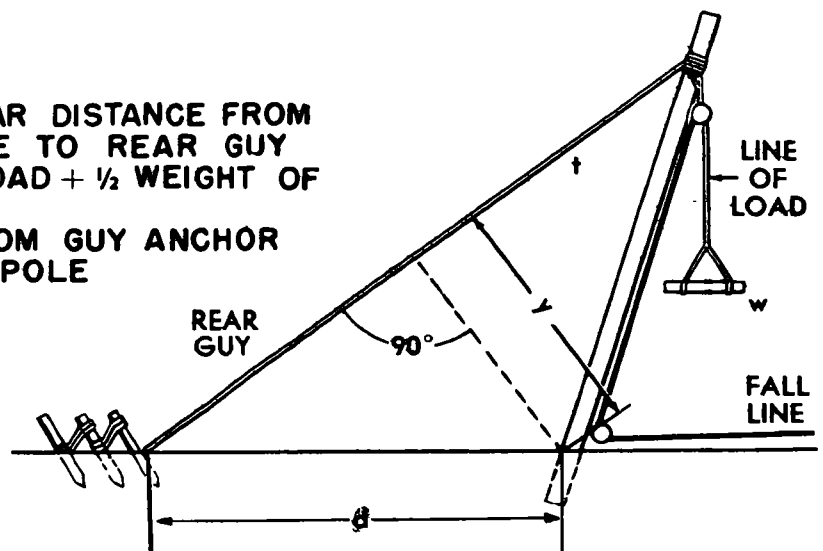


Figure 7.14. Computing guy stress.

Section XIV. TIME, TIDE, AND LIGHT

7.64 Time and Light

a. Designating Time and Date.

- (1) *Time.* Expressed in a group of four digits, ranging from 0000 to 2400. The first two digits are the hours after midnight; the remaining two indicate minutes past the hour. Where the hour can be expressed as a single digit, it is preceded by zero; for example, 0625 for 6:25 a.m.
- (2) *Date.* Day, month, and year expressed in that order—except when necessary to specify a six-digit time group. In a six-digit time group, the first two digits indicate day of month; the next two the hour; the last two, minutes past the hour. For example, 070625 Dec 62 means 6:25 a.m. on 7 Dec 1962. If desired to keep the date secret, dates may be expressed by a letter, such as D plus or minus a numeral in place of the first two digits.
- (3) *Greenwich mean time.* Time groups expressing Greenwich mean time are designated by the letter suffix Z immediately following the last digit of the group; for example, 190225Z.
- (4) *Expressing natural phenomena.* Indefinite terms, such as first light, last light, daybreak, daylight, darkness, dusk, dawn, are avoided. Definite terms are permissible, such as sunrise, sunset, beginning, or end of evening or morning nautical or civil twilight.

b. Time Zone Chart (fig. 7.15).

- (1) The earth averages one rotation on its axis every 24 hours. This causes in the same period an apparent travel of the sun across 360° of longitude. Therefore, the surface of the earth is divided into 24 zones 15° wide in longitude—each 1 hour in width. The initial zone is the one which has the meridian of Greenwich running through the middle of it, and the meridians 7½° east of Greenwich and 7½° west of Greenwich marking its eastern and western limits. It is called the “zero zone” because the difference between the standard time of this zone and Greenwich mean time is zero. Each of the zones in turn is designated

by a number representing the number of hours by which the standard time of the zone differs from Greenwich mean time. The zones lying in east longitude from the zero zone are numbered in sequence from 1 to 12, and are called minus zones because, in each of them, the zone number must be subtracted from the standard time in order to obtain the Greenwich mean time. The zones lying in west longitude from the zero zones are numbered in sequence from 1 to 12, and are called plus zones because, in each of these zones, the zone number must be added to the standard time in order to obtain the Greenwich mean time. The time kept in any zone is the standard time of its central meridian. The twelfth zone is divided medially by the 180° meridian (the line separating the meridians of east longitude from the meridians of west longitude), and the terms “minus” and “plus” are used in the halves of this zone which lie in the east longitude and west longitude, respectively.

- (2) *Use of suffixes.* The suffix letter used after a four- or six-digit time group indicates the number of hours by which the time expressed differs from Greenwich mean time at the same instant. It does not designate location on the earth's surface (fig. 7.15). For example, Norfolk, Va., is located in the fifth time zone west of Greenwich. For local mean time, the suffix letter would be R.

- (3) *Converting time from zone to zone.* The number in the time zone indicates the number of hours or fraction thereof that local time differs from Greenwich mean time. The time zones extend east and west from Greenwich to the 180th meridian. To transpose Greenwich mean time to local time, add the zone number if the zone is east of the prime meridian; subtract it if it is west of the prime meridian. Time conversion for any zone is shown in figure 7.16.

7.65 Tides, Sunlight, and Moonlight

- a. *Chart.* Figure 7.17 shows the type of chart which is issued for each major operation or

Figure 7.15. Time-zone chart.

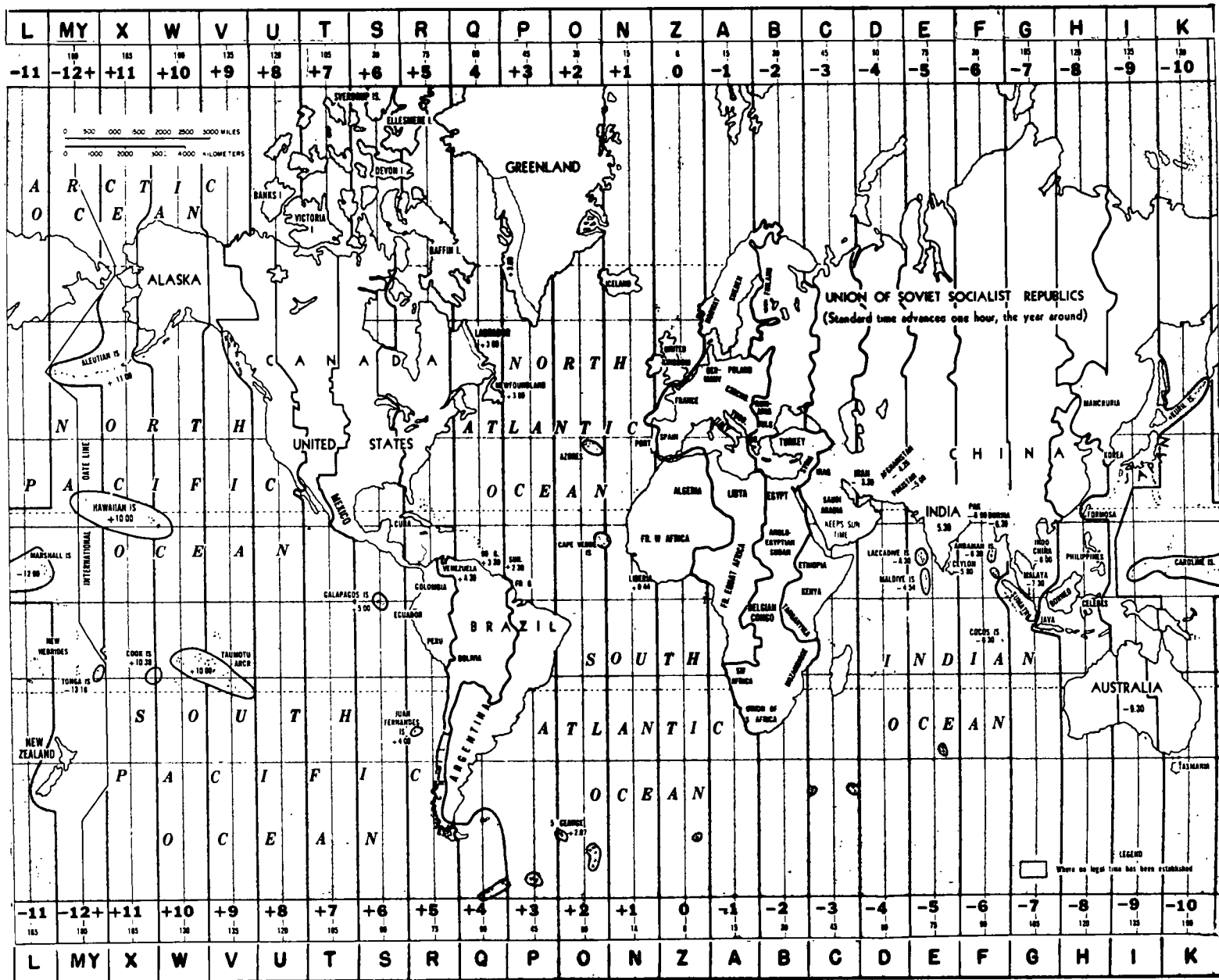


Figure 7.16. Table for conversion of time throughout the world.

TIME ZONE	HOURS OF DAY IN LOCAL MEAN TIME																																																							
	PREVIOUS DAY												SAME DAY																																	NEXT DAY										
	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11								
0 (Z)	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11								
-1 (A)	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12								
-2 (B)	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13								
-3 (C)	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14								
-4 (D)	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15								
-5 (E)	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16								
-6 (F)	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17								
-7 (G)	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18								
-8 (H)	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19								
-9 (I)	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20								
-10 (K)	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21								
-11 (L)	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22								
-12 (M)	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23								
+1 (N)	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10								
+2 (O)	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09								
+3 (P)	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08								
+4 (Q)	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07								
+5 (R)	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06								
+6 (S)	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05								
+7 (T)	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04								
+8 (U)	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03								
+9 (V)	05	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02								
+10 (W)	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01								
+11 (X)	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00								
+12 (Y)	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23								
	PREVIOUS DAY												SAME DAY																																											

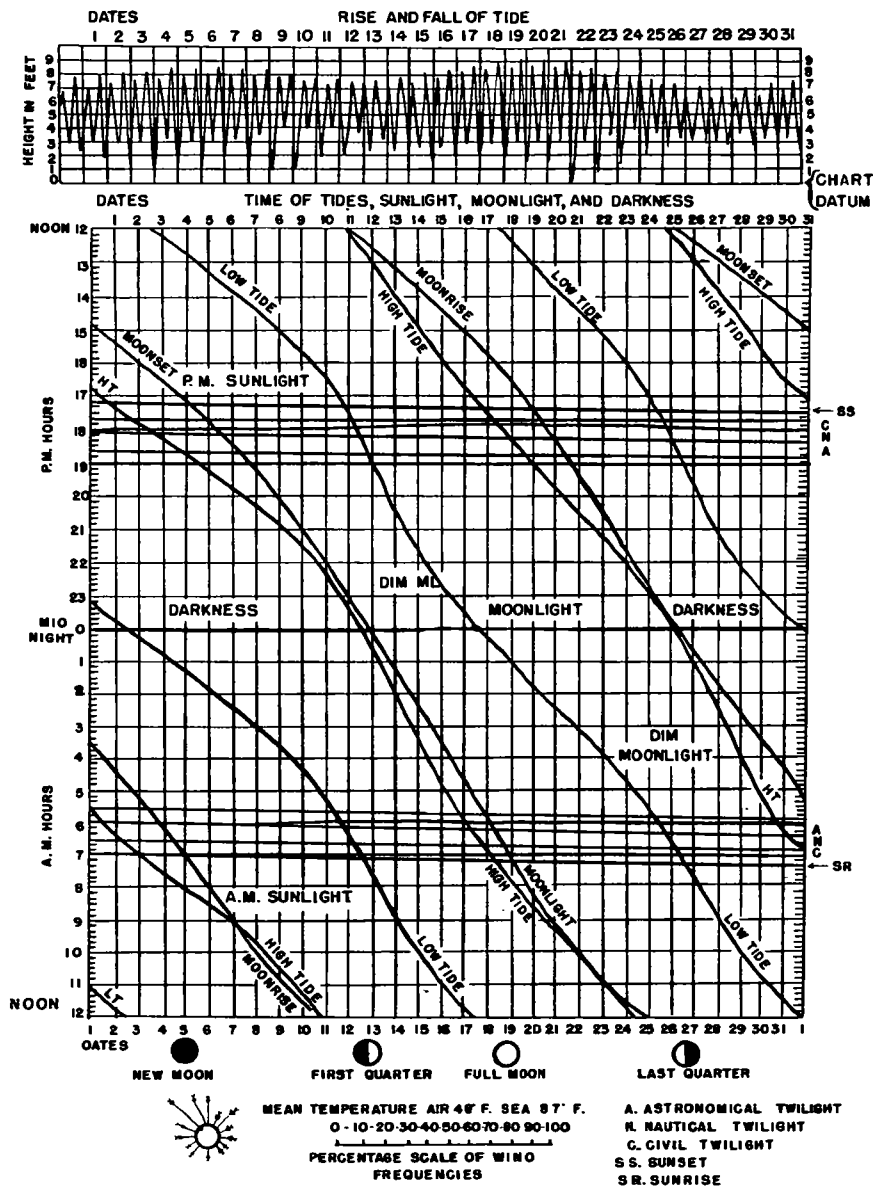
KAGOSHIMA - WAN, KYUSHU *

LAT 31° 30' N., LONG 130° 40' E.

DECEMBER 1945

TIME MERIDIAN: 135° E.

SUNLIGHT AND MOONLIGHT DATA COMPUTED FOR LAT 31° 30' N., LONG 130° 40' E.



* THIS DIAGRAM, WITH THE CHANGES INDICATED, IS ALSO APPLICABLE TO THE FOLLOWING PLACES: TOMARI URA — ADD 10 MINUTES TO TIMES OF HIGH AND LOW TIDES, SUBTRACT 1/2 FOOT FROM HEIGHTS OF HIGH TIDES. ODOMARI-WAN — SUBTRACT 25 MINUTES FROM TIMES OF HIGH AND LOW TIDES, SUBTRACT 1 FOOT FROM HEIGHTS OF HIGH TIDES.

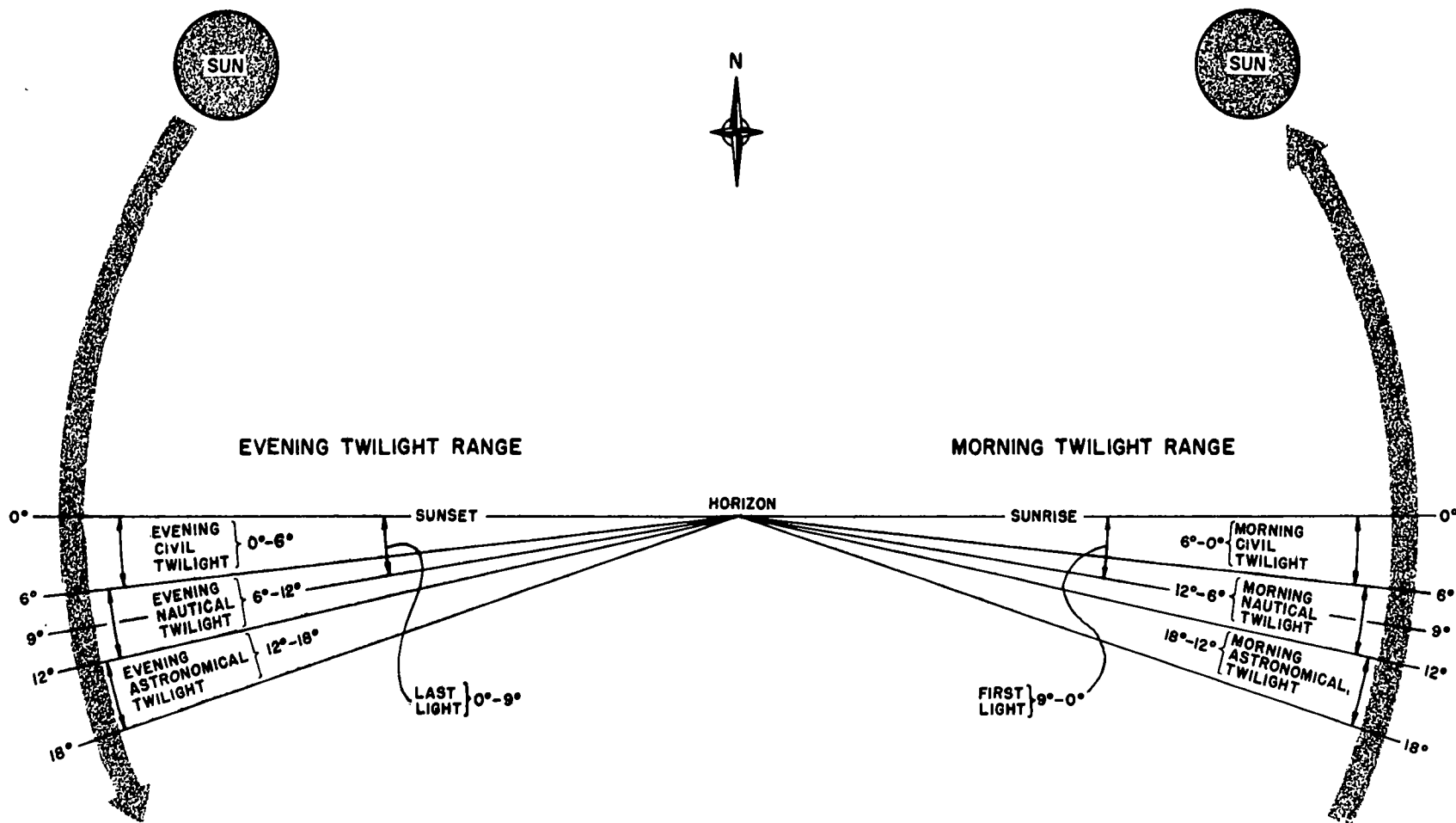
Figure 7.17. Sample diagram of tides, sunlight, and moonlight.

operational area. These charts are prepared by the Joint Intelligence Study Publishing Board and appear in JANIS (Joint Army-Navy Intelligence Study).

b. Area Covered. Astronomical data are for sea level and do not vary more than 5 minutes over a

radius of 60 miles (97 kilometers).

c. Time Used for the Time Meridian Indicated in the Heading. When another time meridian is used in the field, the figures representing hours on the left of the large diagram are changed to conform to the new time. If the time meridian to be used is



NOTE - Degrees refer to center of sun below horizon.

Figure 7.18. Twilight factors.

in a zone number east of the one shown on the diagram, the number is increased by 1 hour for each 15°; if west, the number is decreased by 1 hour for each 15°.

d. Dates. In the upper diagram of figure 7.17, each day from midnight to midnight is represented by a space between two lines. In the lower diagram, the days are represented by vertical lines covering the period from noon of one day to noon of the next. The dates at the bottom of the diagram differ from those at the top because the dates change in passing through midnight.

e. Tides. Times of the tides are shown by curves in the lower diagram. By noting the sequence of the tides during the day, the height of any particular tide can be found by consulting the diagram.

f. Twilight (fig. 7.18).

(1) Twilights are the periods of solar illumination before sunrise and after sunset. Both morning and evening twilights are divided into three periods: astronomical, nautical, and civil.

(a) *Astronomical.* Offers meager light, if any; for military purposes, considered period of darkness.

(b) *Nautical.* Provides enough light to

carry on most types of ground movement without difficulty. Visibility limited to 400 yards (366 meters) or less.

(c) *Civil.* Offers enough light to carry on normal day activities.

(2) Except for high latitudes, durations of astronomical, nautical, and civil twilights may be considered equal.

g. Moonlight. For astronomical twilight and solar darkness, periods of moonlight and solar darkness are shown on the lower diagram of figure 7.17. During the period of moonlight the intensity of light varies between the brightness of the full moon at zenith and about one-third of this value. During the period of dim moonlight, the intensity varies from about one-third to one-tenth of the brightness of the full moon at zenith.

h. Moon's Phases. In figure 7.17 the phases of the moon are shown below the days on which they occur.

i. Effect of Weather on Light. Smog, fog, clouds, refraction, reflection, and precipitation affect the degree of illumination. These factors can be included in the calculations by means of experience tables compiled in the area and from meteorological forecasts for the area.

7.66 Hours of Daylight

[Time between sunrise and sunset. It is light for approximately 30 minutes before sunrise and after sunset. For latitude south, subtract figure given from 24.]

Latitude north	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
0°-----	12	12	12	12	12	12	12	12	12	12	12	12
10°-----	12	12	12	12	13	13	13	12	12	12	12	12
20°-----	11	12	12	13	13	13	13	13	12	12	11	11
30°-----	10	11	12	13	14	14	14	13	12	11	11	10
40°-----	10	11	12	13	14	15	15	14	12	11	10	9
50°-----	9	10	12	14	15	16	16	14	12	11	9	8
60°-----	7	9	12	15	17	19	18	16	12	10	9	6
70°-----	0	7	12	16	23	24	24	18	12	9	4	0
80°-----	0	0	12	24	24	24	24	24	12	5	0	0

7.67 Calendar 1900-1999

a. Calendar.

Key letter¹

Year

T-----	1900			
U-----	1901	1929	1957	1985
V-----	1902	1930	1958	1986
W-----	1903	1931	1959	1987
XY-----	1904	1932	1960	1988
Z-----	1905	1933	1961	1989

Key letter¹

Year

T.....	1906	1934	1962	1990
U.....	1907	1935	1963	1991
VW.....	1908	1936	1964	1992
X.....	1909	1937	1965	1993
Y.....	1910	1938	1966	1994
Z.....	1911	1939	1967	1995
TU.....	1912	1940	1968	1996
V.....	1913	1941	1969	1997
W.....	1914	1942	1970	1998
X.....	1915	1943	1971	1999
YZ.....	1916	1944	1972	
T.....	1917	1945	1973	
U.....	1918	1946	1974	
V.....	1919	1947	1975	
WX.....	1920	1948	1976	
Y.....	1921	1949	1977	
Z.....	1922	1950	1978	
T.....	1923	1951	1979	
UV.....	1924	1952	1980	
W.....	1925	1953	1981	
X.....	1926	1954	1982	
Y.....	1927	1955	1983	
ZT.....	1928	1956	1984	

Month

Key letter

January, October.....	Z	Y	X	W	V	U	T
February, March, November.....	W	V	U	T	Z	Y	X
April, July.....	T	Z	Y	X	W	V	U
May.....	Y	X	W	V	U	T	Z
June.....	V	U	T	Z	Y	X	W
August.....	X	W	V	U	T	Z	Y
September, December.....	U	T	Z	Y	X	W	V

Day

Day of week

1	8	15	22	29	Sun	Sat	Fri	Thurs	Wed	Tues	Mon
2	9	16	23	30	Mon	Sun	Sat	Fri	Thurs	Wed	Tues
3	10	17	24	31	Tues	Mon	Sun	Sat	Fri	Thurs	Wed
4	11	18	25	-----	Wed	Tues	Mon	Sun	Sat	Fri	Thurs
5	12	19	26	-----	Thurs	Wed	Tues	Mon	Sun	Sat	Fri
6	13	20	27	-----	Fri	Thurs	Wed	Tues	Mon	Sun	Sat
7	14	21	28	-----	Sat	Fri	Thurs	Wed	Tues	Mon	Sun

¹ Two letters together are shown for leap years. The first is to be used for January and February, the second for other months.

b. Examples of Use.

- (1) Given March 6, 1962, find the day of the week. Opposite the year 1962 is the key letter *T*. Opposite the month of March, the key letter *T* appears in the fourth column from the left. Under this key letter, opposite the 6th day, Tuesday is found.
- (2) Given Saturday, November_____, 1962, find the possible days of the month that Saturday falls upon. Opposite the year 1962 is the key letter *T*. Opposite the month of November, the key letter *T*

appears in the fourth column from the left. Under the key letter, opposite Saturday, the numbers 3, 10, 17, and 24 are the possible days for November.

- (3) Given Tuesday,_____, 1963, find the possible months in which this combination could occur. Opposite 1963, the key letter *U* is found. Opposite the 6th day, Tuesday appears in the 4th "Day of week" column. Above this column, the key letter *U* is found opposite August.
- (4) Given Monday, February 29,_____,

find the possible year(s). Opposite the 29th day, Monday appears in the last column. Above this column, the key letter X is found opposite February. Since February is shown as having 29

days, it must be a leap year, which means that the first key letter of a 2-letter group must be used. For the key letter X, the possible years are 1904, 1932, 1960, and 1988.

Section XV. TERRAIN FACTORS

7.68 Gradient

Gradient, or slope percentage, is the ratio between the vertical rise and the horizontal distance traveled. This information is sometimes needed by operators in the field, and can be determined from observation on the spot or from maps, by using one of the two methods shown below. The first method, when properly employed with accurate instruments, can give an exact gradient. If accurate instruments are not available or if the accuracy of the first method is in doubt, a workable gradient can be obtained from a map by using the second method. When possible, both methods should be used, so that each can serve as a check upon the other.

a. First Method. With the horizontal bubble leveled in a transit, artillery compass, or similar instrument, sight through the instrument to a point on the terrain; mark the terrain where line of sight intersects. Measure the ground distance in feet to this point and the height in feet (to line of sight) of the instrument. Use the following formula to obtain gradient in percent.

$$\frac{a}{\sqrt{b^2 - a^2}} \times 100 = \text{gradient in percent}$$

Where

a = height of instrument (to line of sight) in feet

b = ground distance in feet between point of sighting and mark on terrain

b. Second Method. Measure the horizontal distance in feet on a map between the two designated points, per map scale. Then measure the change in elevation between the two points by using the map's contour lines. Use the following formula to obtain gradient in percent.

$$\frac{a}{c} \times 100 = \text{gradient in percent}$$

Where

a = change in elevation in feet

c = horizontal distance in feet between the two designated points

7.69 Maps

This paragraph is a brief summary of the essential elements needed for the intelligent and practical use of a relatively large-scale military map. No attempt is made to cover detailed techniques pertaining to orientation, direction, distance, and elevation. The reader should refer to FM 21-26, FM 21-30, and FM 21-31 for more detailed information on map reading.

a. Orienting the Map. A map is oriented when directions on it are parallel with the represented ground directions. In each method outlined below, the map is held in a horizontal position.

- (1) *Inspection.* A straight road, railroad track, or similar feature on the map is made parallel with the same feature on the ground. Care is required to insure that the map is not 180° out of phase.
- (2) *Compass.* The map, with a compass placed upon it, is turned until the compass needle is parallel to the magnetic north arrow on the map.
- (3) *Distant point.* The observer lines up his own position on the map and a distant point on the map with the same distant point on the ground.

b. Recognizing Ground Objects and Places That Also Appear on the Map. The ability of the observer to accomplish this depends upon his experience and the proper use of military map symbols. Natural and manmade shapes and the color scheme of the map must also be understood. On a military map, black represents cultural or manmade features; blue, water; green, vegetation; brown, relief features (contour lines are brown); and red, main roads. Other colors may also be used, such as yellow for contaminated areas.

c. Determination of Horizontal Direction. Horizontal direction is expressed as a clockwise angle (called an azimuth) from true, magnetic, or grid north.

- (1) The three kinds of north are defined below. Marginal information on all military maps should indicate these directions.

- (a) *True north.* The direction that points to the north pole is true north. All lines of longitude (meridians) run true north. These lines are not parallel but intersect at the north and south poles.
- (b) *Magnetic north.* The northern direction indicated by a compass needle is magnetic north. It is affected by many magnetic influences in the earth, chief of which is the magnetic north pole in the vicinity of Melville Island, northern Canada. It may vary considerably with changes in location on the earth's surface and may even show slight variations with changes in time. Therefore, for accurate work, it is mandatory that up-to-date data be used, and that compass readings be as free as possible from surrounding artificial magnetic influences such as those produced by electricity and masses of metal.
- (c) *Grid north.* Grid north is the northern direction that coincides with or is parallel to the vertical lines in a grid system that has been superimposed on a map. These vertical lines are always parallel to each other and should not be confused with true north.
- (2) If magnetic north cannot be determined with a compass, and/or the magnetic declination from true north is not known, an approximate direction of true north can be found by one of the following methods.
- (a) *Use of stars (night).*
1. *Northern hemisphere.* The two pointer stars which form the side of the cup farthest from the handle of the Big Dipper are in line with the North Star, which is located above the North Pole. The distance from the North Star to the nearest pointer star is approximately five times the distance between the pointer stars.
 2. *Southern hemisphere.* The horizontal axis of the constellation known as the Southern Cross (composed of four stars) is used for this determination. A point above the South Pole is to the right of the horizontal axis at an approximate distance of four and a half times the length of the axis. The North Pole (true north) is 180° from the South Pole.
- (b) *Use of a watch set on standard time (day).*
1. *Northern hemisphere.* The hour hand on the watch should be pointed at a direction on the horizon which is directly below the sun. A line bisecting the largest angle between the hour hand and 12 o'clock points north.
 2. *Southern hemisphere.* Point the 12 o'clock position on the watch in a direction which is directly below the sun. A line bisecting the smallest angle between the hour hand and 12 o'clock points north.
- d. *Horizontal Distance and Elevation.*
- (1) *Horizontal distance.* This distance may be expressed in miles, kilometers, feet, yards, meters, or any other approved unit of linear measure (par. 7.47a). To properly apply ground distance to a map, or map distances to the ground, the map's scale must be known. This is usually expressed as a representative fraction (RF). The representative fraction indicates the number of horizontal units (denominator) on the ground that are represented by one horizontal unit (numerator) on the map (par. 7.50). If the map scale is not shown, it can be determined by comparing the map distance between two known points with the measured horizontal ground distance.
 - (2) *Elevation.* This is the vertical distance above or below sea level. On military maps, elevation is usually shown by contour lines, which are lines joining points of equal elevation. The difference in elevation between contour lines is known as the contour interval. This interval should be stated in the margin of a military map and must remain constant for any one map. The amount of the interval depends upon the nature of the surface (a mountainous area has a larger interval than relatively flat terrain). If the contour interval is not indicated, it

can be approximated by using the scale of the map and the following formula:

$$\text{Contour interval} = \frac{60}{\text{Number of map inches to the mile}}$$

e. Point Location in General. On a military map, point location is generally accomplished through the use of polar coordinates or grid coordinates.

- (1) *Polar coordinates.* A direction is determined from the appropriate north discussed in *c* above. A distance along this direction from a base point then gives the point location.
- (2) *Grid coordinates.* A grid system of horizontal and vertical lines (making equal squares) is superimposed upon a map. Point locations are then defined as

horizontal and vertical distance from specified intersections of the grid.

f. Location of Unknown Point from Two Known Positions. Determine a direction to the unknown point from a known position that is occupied. Draw a line on the oriented map along this direction. Move to a new known position to the left or right of the one last occupied, and determine a new direction to the unknown point. Draw another line on the oriented map along this new direction. The intersection of the two lines locates the unknown point on the map.

g. Location of One's Own Position on a Map. Determine directions to two known points that can be seen on the ground and can also be located on the map. Draw lines on the oriented map along both of these directions. The intersection of these lines represents the observer's location on the map.

Section XVI. AIR TRANSPORTABILITY

7.70 Weights, Cubes, and Densities

Line No.	TOE No. (See par. 7.78 for nomenclature)	55-11	55-12	55-16	55-17	55-18 (Cargo)	55-18 (Pet)	55-18 (Refrig)	55-19	55-27	55-46	55-47	55-56	55-57	55-75	55-76	55-77	55-78	55-79	55-111
1	TOE Equipment & Supplies: Cu ft (full str) ¹	1,463.0	1,118.0	774.0	2,661.0	2,131.0	2,143.0	2,245.0	1,730.0	2,062.0	1,289.0	4,171.0	1,585.0	1,865.0	7,812.0	2,390.0	1,083.0	1,676.0	1,293.0	2,727.0
2	ST (full str) ¹	9.6	9.4	7.0	18.9	15.1	15.3	17.5	11.7	14.7	10.5	25.7	13.0	11.6	52.5	20.5	9.5	8.9	9.2	18.2
3	TOE Vehicles & Trailers: ST (full str) ¹	32.0	31.4	36.2	658.0	1,030.7	1,069.7	828.3	177.2	123.3	43.0	1,167.9	50.8	85.2	3,017.6	114.7	616.0	1,112.2	62.5	9.1
4	Troops ¹	124	61	47	168	181	187	200	111	184	55	180	72	147	521	122	156	92	59	303
5	TOE personnel and individual equipment, assuming average weight of 240 lb per man: ¹ ST (full str) ²	14.9	7.3	5.6	20.1	21.7	22.4	24.0	13.3	22.1	6.6	21.6	8.6	17.7	62.5	14.7	18.7	11.0	7.1	36.4
6	Class I necessary for 3 days, assuming 6.6 lb per ration per man per day: Cu ft (full str) ³	103.0	50.3	39.4	139.0	150.0	155.0	166.0	92.2	152.5	46.1	149.0	59.5	122.5	43.6	101.5	129.0	76.3	49.5	250.0
7	ST (full str)	1.23	.6	.47	1.66	1.79	1.85	1.98	1.1	1.82	.55	1.78	.71	1.46	.52	1.21	1.54	.91	.59	2.98
8	Class III necessary to move unit vehicles 300 miles from destination point after arrival, if authorized in shipment: Cu ft (full str) ⁴	28.9	28.4	22.3	490.0	555.0	555.0	555.0	166.5	590.0	31.4	1,820.0	40.7	78.2	4,100.0	169.0	428.0	1,740.0	14.8	8.05
9	ST (full str) ⁴	1.15	1.13	.89	19.53	22.11	22.11	22.11	6.63	23.46	1.25	72.44	1.62	3.11	162.68	6.74	17.05	69.44	.59	.32
10	Basic load of Class V: Cu ft (full str) ⁵	6.58	3.64	2.75	55.5	7.78	9.0	9.5	7.71	20.2	12.75	30.9	7.36	18.0	553.0	19.15	71.7	223.0	9.53	15.35
11	ST (full str) ⁷	.184	.104	.077	1.555	.246	.252	.266	.216	.565	.357	.865	.206	.504	15.52	.536	2.01	6.26	.267	.43
12	Total ST ⁸	59.1	49.9	50.2	719.7	1,091.6	1,131.6	894.1	210.1	185.9	62.3	1,290.3	74.9	119.6	3,311.3	158.4	664.8	1,208.7	80.2	67.4
13	Cube of equipment, supplies, and classes I, III & V ⁹	1,602.0	1,200.0	839.0	3,346.0	2,844.0	2,862.0	2,976.0	1,996.0	2,825.0	1,379.0	6,171.0	1,693.0	2,084.0	12,509.0	2,680.0	1,712.0	3,715.0	1,367.0	3,000.0
14	Density of TOE equipment and supplies, and classes I, III, and V ¹⁰ Cu ft per ST	139.7	113.7	106.2	112.0	109.5	109.1	104.2	127.5	106.8	115.5	107.6	116.3	140.5	93.6	107.2	86.2	84.8	132.5	138.0

See footnotes on page 374.

Line No.	TOE No. (See par. 7.72 for nomenclature)	55-116	55-117	55-121	55-131	55-137	55-147	55-201	55-202	55-225	55-226	55-227	55-228	55-229	55-236	55-260	55-302	55-456	55-457	55-458
1	TOE Equipment & Supplies:																			
2	Cu ft (full str) ¹	644.0	30,224.0	2,050.0	1,702.0	1,976.0	6,179.0	2,217.0	1,230.0	23,921.0	617.0	13,056.0	2,850.0	5,750.0	2,663.0	9,172.0	1,283.0	295.0	2,221.0	2,962.0
	ST (full str) ¹	7.7	245.0	13.7	11.7	17.5	27.4	15.7	9.6	176.6	5.6	106.2	36.2	27.6	13.1	65.1	6.1	2.7	14.6	19.1
3	TOE Vehicles & Trailers:																			
	ST (full str) ¹	25.1	149.9	17.6	16.3	341.5	45.0	54.2	22.9	260.9	24.6	216.9	26.6	6.7	20.4	12.6	40.9	30.6	195.9	122.5
4	Troops ¹	56	329	167	131	194	91	201	101	823	124	251	142	306	102	117	139	33	129	168
5	TOE personnel and individual equipment, assuming average weight of 240 lb per man ¹																			
	ST (full str) ²	6.7	39.5	22.4	15.7	23.3	10.9	24.1	12.1	98.8	14.9	30.2	17.1	36.7	12.1	14.1	16.7	4.0	15.6	20.4
6	Class I necessary for 3 days, assuming 6.6 lb per ration per man per day:																			
7	Cu ft (full str) ³	46.9	273.0	155.0	109.0	161.0	75.5	166.0	83.6	683.0	103.0	209.0	118.0	254.0	64.7	97.2	115.5	27.7	146.5	139.0
	ST (full str)	.56	3.26	1.85	1.3	1.92	.9	1.96	1.0	6.16	1.23	2.49	1.41	3.03	1.01	1.16	1.38	.33	1.77	1.66
8	Class III necessary to move unit vehicles 300 miles from destination point after arrival, if authorized in shipment:																			
9	Cu ft (full str) ⁴	20.3	77.6	7.27	7.27	229.5	35.1	48.0	22.6	129.0	29.4	76.2	13.05	10.8	24.6	33.4	38.9	34.6	135.0	85.1
	ST (full str) ⁵	.81	3.09	.29	.29	9.15	1.4	1.91	.91	5.15	1.17	3.03	.52	.43	.96	1.33	1.55	1.36	5.38	3.39
10	Basic load of Class V:																			
11	Cu ft (full str) ⁶	1.62	20.9	10.2	7.36	23.4	5.75	7.11	5.66	40.9	7.72	15.9	9.26	8.05	6.36	7.36	7.79	3.64	29.7	25.9
	ST (full str) ⁷	.051	.585	.266	.206	.655	.161	.199	.159	1.145	.216	.445	.26	.225	.178	.206	.218	.104	.833	.726
12	Total ST ⁸	40.9	441.3	56.1	47.5	394.0	85.7	98.1	46.7	570.7	47.9	363.3	84.1	76.9	47.8	94.7	66.6	39.1	234.0	167.6
13	Cube of equipment, supplies, & Classes I, III, & V ⁹	913.0	30,596.0	2,223.0	1,826.0	2,390.0	6,295.0	2,438.0	1,342.0	24,774.0	957.0	13,357.0	2,990.0	6,023.0	2,979.0	9,310.0	1,445.0	361.0	2,534.0	3,212.0
14	Density of TOE equipment and supplies, Classes I, III, and V ¹⁰																			
	Cu ft per ST	105.7	124.7	139.4	137.0	100.7	217.0	131.0	121.0	131.6	127.5	118.7	76.6	193.0	207.0	136.5	140.0	96.7	131.0	140.5

¹ Obtained from summation of cube and weight data for TOE personnel and equipment. Cube not shown for vehicles and trailers since configuration is controlling factor (see par. 7.71). Disregard small fluctuations in number of personnel authorized; this will not appreciably affect the aircraft requirement.

² C-119 aircraft has 62 troopseats, but weight capacity limits number of personnel to 57; C-130 aircraft has 92 troopseats; C-124 aircraft has 200 troopseats; but weight capacity limits number of personnel to 169.

³ Computed from weight, using etowage factor of 94.

⁴ Includes only 40 percent of total POL weight (line 9) to be carried in 5-gallon cans. The remaining 60 percent is in vehicle tanks. Factors used are: 1.31 (conversion from bulk to gas in cans); 46.1 cans per ST; 1 cu ft per can.

⁵ POL for vehicles having no roadability (crawler cranes, etc.) has been excluded.

⁶ Computed from weight, using etowage factor of 40.

⁷ Number of weapons times rounds per weapon times weight per round.

⁸ Sum of lines 2, 3, 5, 7, 9, and 11.

⁹ Sum of lines 1, 6, 8, and 10.

¹⁰ Density of equipment and supplies may be used to estimate extent to which vehicle cargo space and other space can be utilized in aircraft. Lines 13 and 14 are for this purpose. Line 14 is obtained by dividing line 13 by the sum of lines 2, 7, 40 percent of line 9, and line 11. Line 14 can also be expressed as a stowage factor by multiplying quantities shown by 1.12.

7.71 Vehicle and Trailer Tonnage Allocations for Aircraft

[illegible]

TOE No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50			
55-78*			4																				57				4																				6.4		1105.8				
55-79*			1			1			2					2						1							1	1	1				3														6.5		55.9				
55-111		1							1																							1																2.7		6.4			
55-116			4			3			1																		4	3	1																			18.7		6.4			
55-117*			3						2				2		2						2	2				1		3			1		1						3		1	1						25.8	13.8	110.3			
55-121			5			1			1																			2		1																			11.2		6.4		
55-131			5			1			1																			2	1		1																		11.9		6.4		
55-137*			4			1			2		38	1			2			1									1		1	1																			30.6	281.2	29.6		
55-147						5			4																								4																	19.4		25.6	
55-201*									3																		4		3	1																				35.0		19.2	
55-202				7					1																																										16.5		6.4
55-225*		1		2	10		3			2				4			7	3	1													4	1						5		5		4		2	1	4	10	20	127.6	87.3	66.0	
55-226		1			5												4																																		24.8		
55-227*			2			3				2				4				3	1														3	1						5		5		2		1	3	10	20	65.4	87.4	66.0	
55-228				2													2																																		28.6		
55-229				3													1																																		8.7		
55-236				2				1									4																																	20.4			
55-260			1			1			1																			1	1		1																				6.4		6.4
55-302		2		10			3			2																		6			1																			28.1		12.8	
55-456			5			2			2																			5	2	2																					17.8		12.8
55-457*			4			3			11			6			1				3	1								2	1	10	1			3		1															64.0	27.6	104.3
55-458*			2			2			5			7								1	1							1		8	1			1		1															54.6	9.2	58.8

1 Vehicles for C-119 loading: (columns 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 15, 16, 27, 28, 29, 30, 31, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47)

Vehicles for C-130 loading: (columns 11, 13, 19, 24, 37)

Vehicles for C-124 loading: (columns 9, 14, 17, 18, 20, 21, 22, 23, 25, 26, 32, 33, 34, 35, 36)

2 Figures shown are useful for general planning. When loading specific vehicles that are identified by a model number, the actual dimensions and weight must be determined beforehand. It must also be borne in mind for all vehicles that assembly produces slight variations in size, even for the same make and model number.

3 Following usable aircraft capacities apply:

Length Width Height

Width Height

C-119—ST capacity (6.815); cargo compt, inches (443 × 110 × 96); door opening, inches (110 × 96)

C-130—ST capacity (14.760); cargo compt, inches (498 × 123 × 109); door opening, inches (120 × 110)

C-124—ST capacity (20.250); cargo compt, inches (924 × 136 × 138); door opening, inches (135 × 139)

4 Units indicated by asterisk (*) require increase in heavy aircraft requirement due to the peculiar configuration of certain vehicles and trailers. Maximum tonnage capacity of aircraft cannot be utilized. See paragraph 7.72 for increase required.

7.72 Air Transportability

a. General. Data in the two preceding paragraphs are used in conjunction with other data to construct the air-transportability table shown in *c* below. The table, consisting of 43 columns, indicates to the transportation planner a logical sequence in planning the movement of transportation units by Air Force aircraft. In obtaining the figures shown in columns 39 through 42 (notes 14 through 17), any fractional portion of an aircraft in the totals is considered as a whole aircraft. Figures in parentheses show the basic aircraft requirement when 60 percent of the POL load is carried in vehicles. Only those units shown are affected. POL load for the others is negligible. See line 9 of the table in paragraph 7.70.

b. Loading. The planner should not feel bound by the loading combinations shown below. Other combinations can be used.

- (1) *Method 1.* Method 1 utilizes C-119 and C-124 aircraft only. Maximum load in C-119's includes all equipment, supplies, personnel, and individual equipment and some of the vehicles and trailers. The remainder of the load, consisting of vehicles and trailers, is transported by C-124's. Vehicle and trailer loads in column 15 are placed in C-119 aircraft; the loads in columns 16 and 17 are placed in C-124's.
- (2) *Method 2.* Method 2 utilizes C-130 and C-124 aircraft only. The C-119 load goes in the C-130's. The C-124 load remains the same except for those units having equipment that does not fit into C-119's but does fit in C-130's. In the cases of these units (55-18, -56, -57, -117, -137, -225, -227, -457, and -458), the C-130's transport some of the vehicles which were allotted to C-124's by method 1. Vehicle and trailer loads in columns 15 and 16 are placed in C-130 aircraft; the loads in column 17 are placed in C-124's.
- (3) *Adjustments due to configuration.* Units indicated in this subparagraph need more or less aircraft due to configuration of certain vehicles and trailers. (See note 4,

par. 7.71.) For determining the aircraft requirement change, only columns 25 through 28 in the table are used, since columns 12, 13, 14, 36, 37, and 38 do not pertain to vehicles and trailers. The increased vehicle configuration requirement for heavy aircraft, which does not utilize their maximum tonnage capacity, may result in a decrease in the requirement for medium aircraft, since some or all of the cargo from columns 3 and 4 in the table can be loaded into the cargo space of vehicles. Increase or decrease in requirement will be as shown below, with increase denoted by "+," and decrease denoted by "-." Any decrease in requirement cannot be greater than the actual requirement for equipment and supplies indicated by columns 12 and 13 in the table.

- (4) *Personnel loading.* When loading personnel with their individual equipment (columns 30 through 35 in the table), either troop seat capacity or the weight of 240 pounds per man produces the limiting factors. Weight is the limiting factor for the C-119 and the C-124 and volume for the C-130.
- (5) *Use of heavy aircraft only.* Should C-124 aircraft be used exclusively, vehicle and trailer configuration assumes less importance. Therefore, a rapid and close approximation of the number of aircraft required (except for units organized under TOE 55-18) can be arrived at through use of the formula shown below. In most cases the estimate allows for a safety factor of one aircraft. (See line 12 of the table in paragraph 7.70 for values of W in the formula.)

$$\text{Aircraft required} = \frac{W}{20.25} + 1$$

In the case of TOE 55-18 units, aircraft in addition to those called for by the formula would be required as follows:

TOE 55-18 (cargo)—9
TOE 55-18 (petrl)—7
TOE 55-18 (refrig)—3

Unit TOE No.	Loading method	C-119	C-130	C-124	Unit TOE No.	Loading method	C-119	C-130	C-124
55-12	1 2	-1		+1 +1	55-78	1 2			+2 +2
55-18 (cargo)	1 2	-3	+21	+13 +11	55-79	1 2	-1		+2 +2
55-18 (petrl)	1 2	-2	+20	+12 +8	55-117	1 2	-1		+1
55-18 (refrig)	1 2	-3	+21	+14 +11	55-137	1 2	-3	+16	+5
55-19	1 2	-1		+1 +1	55-201	1 2	-1		+1 +1
55-27	1 2	+8	+1		55-225	1 2	-3		+3 +1
55-47	1 2	-4	-2	+3 +3	55-227	1 2	-4		+4 +1
55-75	1 2	-19	-9	+23 +23	55-457	1 2	-2	-1	+3 +3
55-76	1 2	-2	-1	+2 +2	55-458	1 2	-1	-1	+1 +2
55-77	1 2	-1	-1	+14 +14					

c. Air-transportability Table.

UNIT	TOE No.	EQUIPMENT AND SUPPLIES ¹											
		Total Cu Ft ³	Total Weight (ST) ²	Average density of equip and supplies (Cu Ft per ST) ³	Aircraft requirements ⁴								
					Minimum required for volume loading			Minimum required for weight loading			Number actually required by cube or weight		
					C-119 Method ⁵ 1	C-130 Method ⁶ 2	C-124	C-119 Method ⁵ 1	C-130 Method ⁶ 2	C-124	C-119 Method ⁷ 1	C-130 Method ⁸ 2	C-124
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Hq & Hq Co, Trans Mtr Transport Comd.....	55-11	1,602	11.47	139.7	.59	.41	-----	1.63	.78	-----	1.63	.78	
Hq & Hq Co, Trans Trk Gp.....	55-12	1,200	10.56	113.7	1.44	.31	-----	1.55	.72	-----	1.55	.72	
Hq & Hq Det, Trans Trk Bn, Army or COMMZ.....	55-16	839	7.90	106.2	.31	.22	-----	1.16	.54	-----	1.16	.54	
Trans Lt Trk Co.....	55-17	3,346	29.93	112.0	1.24	.86	-----	4.40	2.03	-----	4.40	2.03	
Trans Med Trk Co (Cargo).....	55-18	2,844	25.98	109.5	1.06	.73	-----	3.82	1.76	-----	3.82	1.76	
Trans Med Trk Co (Petroleum).....	55-18	2,862	26.25	109.1	1.06	.74	-----	3.86	1.78	-----	3.86	1.78	
Trans Med Trk Co (Refrigerator).....	55-18	2,976	28.59	104.2	1.10	.77	-----	4.20	1.94	-----	4.20	1.94	
Trans Car Co.....	55-19	1,996	15.67	127.5	.74	.52	-----	2.30	1.06	-----	2.30	1.06	
Trans Cargo Carrier Co (Tracked) ..	55-27	2,825	26.47	106.8	1.05	.73	-----	3.90	1.80	-----	3.90	1.80	
Hq & Hq Det, Trans Tactical Carrier Bn.....	55-46	1,379	11.91	115.5	.51	.36	-----	1.75	.81	-----	1.75	.81	
Trans Tactical Carrier Co.....	55-47	6,171	57.32	107.6	2.29	1.59	-----	8.42	3.89	-----	8.42	3.89	
Hq & Hq Det, Trans Transport Acft Bn.....	55-56	1,693	14.56	116.3	.63	.44	-----	2.14	.99	-----	2.14	.99	
Tans Lt Helicopter Co.....	55-57	2,084	14.81	140.5	.77	.54	-----	2.18	1.01	-----	2.18	1.01	
Inf Div Trans Bn.....	55-75	12,509	133.61	93.6	4.63	3.23	-----	19.60	9.06	-----	19.60	9.06	
Hq & Hq Co, Inf Div Trans Bn.....	55-76	2,680	24.94	107.2	.99	.69	-----	3.66	1.69	-----	3.66	1.69	
Trk Trans Co, Inf Div Trans Bn.....	55-77	1,712	19.87	86.2	.63	.44	-----	2.93	1.35	-----	2.93	1.35	
Armored Carrier Co, Inf Div Trans Bn.....	55-78	3,715	43.85	84.8	1.38	.96	-----	6.45	2.97	-----	6.45	2.97	
Inf or Armored Div Trans Acft Maint Det.....	55-79	1,367	10.29	132.5	.51	.35	-----	1.51	.70	-----	1.51	.70	
Hq & Hq Co, Trans Term Comd C.....	55-111	3,000	21.74	138.0	1.11	.78	-----	3.19	1.47	-----	3.19	1.47	
Hq & Hq Det, Trans Term Bn.....	55-116	913	8.64	105.7	.34	.24	-----	1.27	.59	-----	1.27	.59	
Trans Term Svc Co.....	55-117	30,596	250.08	124.7	11.35	7.91	-----	36.80	16.95	-----	36.80	16.95	
Hq & Hq Co, Trans Term Comd B.....	55-121	2,223	15.95	139.4	.82	.58	-----	2.34	1.08	-----	2.34	1.08	
Hq & Hq Co, Trans Term Comd A.....	55-131	1,826	13.32	137.0	.70	.47	-----	1.95	.90	-----	1.95	.90	
Trans Amphib Trk Co.....	55-137	2,390	23.74	100.7	.88	.59	-----	3.48	1.61	-----	3.48	1.61	
Trans Staging Area Co.....	55-147	6,295	29.02	217.0	2.33	1.62	-----	4.27	1.97	-----	4.27	1.97	

See footnotes on page 380.

UNIT	TOE No.	EQUIPMENT AND SUPPLIES ¹											
		Total Cu Ft ²	Total Weight (ST) ³	Average density of equip and supplies (Cu Ft per ST) ³	Aircraft requirements ⁴								
					Minimum required for volume loading			Minimum required for weight loading			Number actually required by cube or weight		
					C-119 Method ⁵ 1	C-180 Method ⁶ 2	C-124	C-119 Method ⁵ 1	C-180 Method ⁶ 2	C-124	C-119 Method ⁷ 1	C-180 Method ⁸ 2	C-124
1	2	3	4	5	6	7	8	9	10	11	12	13	14
GHQ, Trans Railway Svc.....	55-201	2,438	18.64	131.0	.90	.63	-----	2.74	1.26	-----	2.74	1.26	
Hq & Hq Co, Trans Railway Gp.....	55-202	1,342	11.12	121.0	.50	.35	-----	1.64	.75	-----	1.64	.75	
Trans Railway Operating Bn.....	55-225	24,774	187.96	131.6	9.17	6.40	-----	27.60	12.75	-----	27.60	12.75	
Hq & Hq Co, Trans Railway Operating Bn.....	55-226	957	7.51	127.5	.36	.25	-----	1.10	.51	-----	1.10	.51	
Railway Engineering Co, Trans Railway Op Bn.....	55-227	13,357	112.35	118.7	4.95	3.45	-----	16.50	7.61	-----	16.50	7.61	
Railway Equipment Co, Trans Railway Op Bn.....	55-228	2,990	38.08	78.6	1.11	.77	-----	5.60	2.58	-----	5.60	2.58	
Train Operating Co, Trans Railway Op Bn.....	55-229	6,023	31.23	193.0	2.23	1.56	-----	4.58	2.12	-----	4.58	2.12	
Hq & Hq Co, Trans Railway Shop Bn.....	55-236	2,979	14.68	207.0	1.10	.77	-----	2.15	.99	-----	2.15	.99	
Trans Depot Co.....	55-260	9,310	66.99	138.5	3.45	2.40	-----	9.84	4.54	-----	9.84	4.54	
Hq & Hq Co, Trans Railway Comd.....	55-302	1,445	10.32	140.0	.54	.37	-----	1.51	.70	-----	1.51	.70	
Hq & Hq Det, Trans Army Acft Maint & Sup Bn.....	55-456	361	3.69	98.7	.13	.09	-----	.54	.25	-----	.54	.25	
Trans Army Acft Direct Support Co.....	55-457	2,534	19.36	131.0	.94	.65	-----	2.85	1.32	-----	2.85	1.32	
Trans Army Acft Hv Maint & Sup Co.....	55-458	3,212	22.84	140.5	1.19	.83	-----	3.36	1.55	-----	3.36	1.55	

¹ Does not include aircraft or overweight and outsize vehicles or equipment. Typical aircraft loads, to include center of gravity, are not included in this table. If distance is too great for Army aircraft in units to fly and these aircraft must be loaded in Air Force aircraft, see appropriate TM (-s series), "Preparation for Shipment of Army Aircraft" or TM 55-450 series. Any additional Air Force aircraft required will be in addition to the requirement shown in this table.

² The following usable cargo cube and weight capacities of aircraft apply. For columns 3 and 4, equipment and supplies include TOE equipment (except vehicles and trailers), Class I, 40 percent of Class III, and Class V. For personnel loading, see notes 1 and 2, paragraph 7.70. Disregard small fluctuations in number of personnel authorized; this will not appreciably affect the aircraft requirement.

C-119: 2,700 cu ft and 6.815 ST (cargo compartment—448 × 110 × 96; door—110 × 96)

C-180: 3,870 cu ft and 14.75 ST (cargo compartment—493 × 123 × 109; door—120 × 110)

C-124: 10,000 cu ft and 20.25 ST (cargo compartment—924 × 186 × 133; door—185 × 139)

³ Column 3 divided by 2,700.

⁴ Column 3 divided by 3,870.

⁵ Column 4 divided by 6.815.

⁶ Column 4 divided by 14.75.

⁷ Use the larger quantities in columns 6 or 9 for column 12.

⁸ Use the larger quantities in columns 7 or 10 for column 13.

UNIT	VEHICLES AND TRAILERS ¹													
	Aircraft load distribution			Aircraft requirements ²										
	C-119 (ST) ³	C-180 (ST) ³	C-124 (ST) ³	Minimum required for volume loading ⁴			Minimum required for weight loading				Number actually required by weight			
				C-119 Method 1	C-180 Method 2	C-124	C-119 Method ¹⁰ 1	C-180 Method ¹¹ 2	C-124 Method ¹² 1	C-124 Method ¹² 2	C-119 Method ¹⁰ 1	C-180 Method ¹¹ 2	C-124 Method ¹² 1	C-124op Meth ¹³ 2
	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Hq & Hq Co, Trans Mtr Trans- port Comd.....	25.6	-----	6.4	See paragraph 7.72b(3)	See paragraph 7.72b(3)	See paragraph 7.72b(3)	3.75	1.73	.32	.32	3.75	1.73	.32	.32
Hq & Hq Co, Trans Trk Gp.....	18.6	-----	12.8				2.73	1.26	.63	.63	2.73	1.26	.63	.63
Hq & Hq Det, Trans Trk Bn, Army or COMMZ.....	29.8	-----	6.4				4.37	2.02	.32	.32	4.37	2.02	.32	.32
Trans Lt Trk Co.....	40.1	-----	619.0				5.88	2.72	30.40	30.40	5.88	2.72	30.40	30.40
Trans Med Trk Co (Cargo).....	13.0	561.0	457.0				1.91	38.90	50.40	22.60	1.91	38.90	50.40	22.60
Trans Med Trk Co (Petroleum)...	16.0	561.0	493.0				2.35	39.10	52.10	24.30	2.35	39.10	52.10	24.30
Trans Med Trk Co (Refrigerator)...	14.0	561.0	254.0				2.05	39.00	40.20	12.50	2.05	39.00	40.20	12.50
Trans Car Co.....	157.2	-----	20.8				23.00	10.70	1.03	1.03	23.00	10.70	1.03	1.03
Trans Cargo Carrier Co (Tracked)...	123.3	-----	-----				18.10	8.33	-----	-----	18.10	8.33	-----	-----
Hq & Hq Det, Trans Tactical Carrier Bn.....	30.2	-----	12.8				4.43	2.05	.63	.63	4.43	2.05	.63	.63
Trans Tactical Carrier Co.....	30.1	-----	1137.8				4.42	2.04	56.20	56.20	4.42	2.04	56.20	56.20
Hq & Hq Det, Trans Transport Acft Bn.....	27.5	10.5	12.8				4.03	2.58	1.15	.63	4.03	2.58	1.15	.63
Trans Lt Helicopter Co.....	49.1	10.5	25.6				7.20	4.04	1.78	1.27	7.20	4.04	1.78	1.27
Inf Div Trans Bn.....	157.0	-----	2860.5				23.00	10.65	141.40	141.40	23.00	10.65	141.40	141.40
Hq & Hq Co, Inf Div Trans Bn...	33.7	-----	81.0				4.95	2.29	4.00	4.00	4.95	2.28	4.00	4.00
Trk Trans Co, Inf Div Trans Bn...	104.0	-----	512.0				15.30	7.05	25.30	25.30	15.30	7.05	25.30	25.30
Armored Carrier Co, Inf Div Trans Bn.....	6.4	-----	1105.8				.94	.43	54.60	54.60	.94	.43	54.60	54.60
Inf or Armored Div Trans Acft Maint Det.....	6.5	-----	55.9				.95	.44	2.76	2.76	.95	.44	2.76	2.76
Hq & Hq Co, Trans Term Comd C...	2.7	-----	6.4				.39	.18	.32	.32	.39	.18	.32	.32
Hq & Hq Det, Trans Term Bn...	18.7	-----	6.4				2.74	1.27	.32	.32	2.74	1.27	.32	.32
Trans Term Svc Co.....	25.8	13.8	110.3				3.79	2.68	6.13	5.45	3.79	2.68	6.13	5.45
Hq & Hq Co, Trans Term Comd B...	11.2	-----	6.4				1.64	.76	.32	.32	1.64	.76	.32	.32
Hq & Hq Co, Trans Term Comd A...	11.9	-----	6.4				1.75	.81	.32	.32	1.75	.81	.32	.32
Trans Amphib Trk Co.....	30.6	281.2	29.6				4.49	21.10	15.40	1.46	4.49	21.10	15.40	1.46
Trans Staging Area Co.....	19.4	-----	25.6				2.84	1.32	1.27	1.27	2.84	1.32	1.27	1.27

¹ See footnotes on page 382.

UNIT	VEHICLES AND TRAILERS ^a													
	Aircraft load distribution			Aircraft requirements ^a										
	C-119 (ST) ^a	C-180 (ST) ^a	C-124 (ST) ^a	Minimum required for volume loading ^a			Minimum required for weight loading				Number actually required by weight			
				C-119 Method 1	C-180 Method 2	C-124	C-119 Method ¹⁰ 1	C-180 Method ¹¹ 2	C-124 Method ¹² 1	C-124 Method ¹³ 2	C-119 Method ¹⁰ 1	C-180 Method ¹¹ 2	C-124 Method ¹² 1	C-124 Method ¹³ 2
15	16	17	18	19	20	21	22	28	24	25	26	27	28	
GHQ, Trans Railway Svc.....			19.2				5.13	2.37	.95	.95	5.13	2.37	.95	.95
Hq & Hq Co, Trans Railway Gp..	16.5	35.0	6.4				2.42	1.12	.32	.32	2.42	1.12	.32	.32
Trans Railway Operating Bn.....	127.6	87.3	66.0				18.70	14.60	7.57	3.26	18.70	14.60	7.57	3.26
Hq & Hq Co, Trans Railway Operating Bn.....	24.8						3.64	1.68			3.64	1.68		
Railway Engineering Co, Trans Railway Op Bn.....	65.4	87.4	66.0				9.58	10.35	7.58	3.26	9.58	10.35	7.58	3.26
Railway Equipment Co, Trans Railway Op Bn.....	28.6						4.19	1.94			4.19	1.94		
Train Operating Co, Trans Rail- way Op Bn.....	8.7						1.28	.59			1.28	.59		
Hq & Hq Co, Trans Railway shop Bn.....	20.4						2.97	1.39			2.97	1.39		
Trans Depot Co.....	6.4		6.4				.94	.43	.32	.32	.94	.43	.32	.32
Hq & Hq Co, Trans Railway Comd.....	28.1		12.8				4.12	1.90	.63	.63	4.12	1.90	.63	.63
Hq & Hq Det, Trans Army Acft Maint & Sup Bn.....	17.8		12.8				2.61	1.21	.63	.63	2.61	1.21	.63	.63
Trans Army Acft Direct Support Co.....	64.0	27.6	104.3				9.40	6.21	6.52	5.15	9.40	6.21	6.52	5.15
Trans Army Acft Hv Maint & Sup Co.....	54.6	9.2	58.8				8.00	4.33	3.37	2.91	8.00	4.33	3.37	2.91

^a See paragraph 7.7 for vehicles, configuration, and loading.

¹⁰ Column 15 divided by 6.815 (used with method 1).

¹¹ Column 15 plus column 16 divided by 14.75 (used with method 2).

¹² Column 16 plus column 17 divided by 20.25 (used with method 1).

¹³ Column 17 divided by 20.25 (used with method 2).

(See page 380 for footnotes 1-8.)

UNIT	PERSONNEL AND INDIVIDUAL EQUIPMENT										BASIC AIRCRAFT REQUIREMENT TO LIFT UNIT				TOE No.
	Troops ^a	Aircraft requirements ^a									C-119 Method 1 ¹⁴	C-130 Method 2 ¹⁴	C-124 Method 1 ¹⁶	C-124 Method 2 ¹⁷	
		Minimum required for volume loading (troop seats in parenthesis)			Minimum required for weight loading (240 pounds per man)			Number actually required by cube or weight							
		C-119 Method 1 (62)	C-130 Method 2 (92)	C-124 (200)	C-119 Method 1	C-130 Method 2	C-124	C-119 Method 1	C-130 Method 2	C-124					
	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Hq & Hq Co, Trans Mtr Trans- port Comd.....	124	-----	1.35	-----	2.18	-----	-----	2.18	1.35	-----	8	4	1	1	55-11
Hq & Hq Co, Trans Trk Gp.....	61	-----	.66	-----	1.07	-----	-----	1.07	.66	-----	6	3	1	1	55-12
Hq & Hq Det, Trans Trk Bn, Army or COMMZ.....	47	-----	.51	-----	.83	-----	-----	.83	.51	-----	7	4	1	1	55-16
Trans Lt Trk Co.....	168	-----	1.83	-----	2.95	-----	-----	2.95	1.83	-----	14	7	31 (32)	31 (32)	55-17
Trans Med Trk Co (Cargo).....	181	-----	1.97	-----	3.18	-----	-----	3.18	1.97	-----	9	43 (44)	51 (52)	23 (24)	55-18 (c)
Trans Med Trk Co (Petroleum) ..	187	-----	2.04	-----	3.28	-----	-----	3.28	2.04	-----	10	43 (44)	53 (54)	25 (26)	55-18 (p)
Trans Med Trk Co (Refrigerator) ..	200	-----	2.18	-----	3.51	-----	-----	3.51	2.18	-----	10	44 (45)	41 (42)	13 (14)	55-18 (r)
Trans Car Co.....	111	-----	1.21	-----	1.95	-----	-----	1.95	1.21	-----	28 (29)	13 (14)	2	2	55-19
Trans Cargo Carrier Co (Tracked) ..	184	-----	2.00	-----	3.23	-----	-----	3.23	2.00	-----	26 (29)	13 (14)	-----	-----	55-27
Hq & Hq Det, Trans Tactical Carrier Bn.....	55	-----	.60	-----	.97	-----	-----	.97	.60	-----	8	4	1	1	55-46
Trans Tactical Carrier Co.....	180	-----	1.96	-----	3.16	-----	-----	3.16	1.96	-----	16	8	57 (59)	57 (59)	55-47
Hq & Hq Det, Trans Transport Acft Bn.....	72	-----	.78	-----	1.26	-----	-----	1.26	.78	-----	8	5	2	1	55-56 ¹⁸
Trans Lt Helicopter Co.....	147	-----	1.60	-----	2.58	-----	-----	2.58	1.60	-----	12	7	2	2	55-57 ¹⁸
Inf Div Trans Bn.....	521	-----	5.67	-----	9.32	-----	-----	9.32	5.67	-----	52	26	142 (147)	142 (147)	55-75 ¹⁸
Hq & Hq Co, Inf Div Trans Bn....	122	-----	1.33	-----	2.14	-----	-----	2.14	1.33	-----	11	6	4	4	55-76
Trk Trans Co, Inf Div Trans Bn....	156	-----	1.70	-----	2.74	-----	-----	2.74	1.70	-----	21	11	26 (27)	26 (27)	55-77
Armored Carrier Co, Inf Div Trans Bn.....	92	-----	1.00	-----	1.61	-----	-----	1.61	1.00	-----	9	5	55 (57)	55 (57)	55-78
Inf or Armored Div Trans Acft Maint Det.....	59	-----	.64	-----	1.04	-----	-----	1.04	.64	-----	4	2	3	3	55-79 ¹⁸
Hq & Hq Co, Trans Term Comd C....	303	-----	3.30	-----	5.36	-----	-----	5.36	3.30	-----	9	5	1	1	55-111
Hq & Hq Det, Trans Term Bn....	56	-----	.61	-----	.98	-----	-----	.98	.61	-----	5	3	1	1	55-116
Trans Term Svc Co.....	329	-----	3.58	-----	5.78	-----	-----	5.78	3.58	-----	47	24	7	6	55-117
Hq & Hq Co, Trans Term Comd B....	187	-----	2.04	-----	3.28	-----	-----	3.28	2.04	-----	8	4	1	1	55-121
Hq & Hq Co, Trans Term Comd A....	131	-----	1.42	-----	2.30	-----	-----	2.30	1.42	-----	6	4	1	1	55-131
Trans Amphib Trk Co.....	194	-----	2.11	-----	3.41	-----	-----	3.41	2.11	-----	12	25 (26)	16	2	55-137
Trans Staging Area Co.....	91	-----	.99	-----	1.60	-----	-----	1.60	.99	-----	9	5	2	2	55-147

See footnotes on page 384.

UNIT	PERSONNEL AND INDIVIDUAL EQUIPMENT									BASIC AIRCRAFT REQUIREMENT TO LIFT UNIT				TOE No	
	Troops ^a	Aircraft requirements ^a									C-119 Method 1 ¹⁴	C-180 Method 2 ¹⁵	C-124 Method 1 ¹⁶		C-124 Method 2 ¹⁷
		Minimum required for volume loading (troop seats in parenthesis)			Minimum required for weight loading (240 pounds per man)			Number actually required by cube or weight							
		C-119 Method 1 (62)	C-180 Method 2 (92)	C-124 (200)	C-119 Method 1	C-180 Method 2	C-124	C-119 Method 1	C-180 Method 2	C-124					
	29	80	81	82	88	84	85	86	87	88	89	40	41	42	48
GHQ, Trans Railway Svc.....	201	-----	2.19	-----	3.54	-----	-----	3.54	2.19	-----	12	6	1	1	55-201
Hq & Hq Co, Trans Railway Gp.....	101	-----	1.10	-----	1.77	-----	-----	1.77	1.10	-----	6	3	1	1	55-202
Trans Railway Operating Bn.....	823	-----	8.95	-----	14.45	-----	-----	14.45	8.95	-----	61	37	8	4	55-225
Hq & Hq Co, Trans Railway Operating Bn.....	124	-----	1.35	-----	2.18	-----	-----	2.18	1.35	-----	7	4	-----	-----	55-226
Railway Engineering Co, Trans Railway Op Bn.....	251	-----	2.74	-----	4.40	-----	-----	4.40	2.74	-----	31	21	8	4	55-227
Railway Equipment Co, Trans Railway Op Bn.....	142	-----	1.55	-----	2.49	-----	-----	2.49	1.55	-----	13	7	-----	-----	55-228
Train Operating Co, Trans Rail- way Op Bn.....	306	-----	3.32	-----	5.38	-----	-----	5.38	3.32	-----	12	7	-----	-----	55-229
Hq & Hq Co, Trans Railway Shop Bn.....	102	-----	1.11	-----	1.79	-----	-----	1.79	1.11	-----	7	4	-----	-----	55-236
Trans Depot Co.....	117	-----	1.27	-----	2.05	-----	-----	2.05	1.27	-----	13	7	1	1	55-260
Hq & Hq Co, Trans Railway Comd.....	139	-----	1.51	-----	2.44	-----	-----	2.44	1.51	-----	9	5	1	1	55-302
Hq & Hq Det, Trans Army Acft Maint & Sup Bn.....	33	-----	.36	-----	.58	-----	-----	.58	.36	-----	4	2	1	1	55-456
Trans Army Acft Direct Support Co.....	129	-----	1.40	-----	2.27	-----	-----	2.27	1.40	-----	15	9	7	6	55-457 ¹⁸
Trans Army Acft Hv Maint & Sup Co.....	168	-----	1.83	-----	2.95	-----	-----	2.95	1.83	-----	15	8	4	3	55-458 ¹⁸

14 Sum of columns 12, 25, and 36 (used with method 1)

¹⁴ Sum of columns 12, 25, and 86 (used with method 1).¹⁵ Sum of columns 18, 26, and 87 (used with method 2).¹⁶ Sum of columns 14, 27, and 88 (used with method 1).¹⁷ Sum of columns 14, 28, and 88 (used with method 2).¹⁸ Figures do not include all aircraft shop and tool sets (accurate weight and cube data not available). (See pages 380 and 382 for footnotes 1-18.)

APPENDIX I

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- 59-8 Air Transportation Space and Capability.
- 59-22 Requests for Transportation by Other Than Scheduled Flights of Military Air Transport Service.
- 59-106 Operation of Air Force Terminals.
- 59-132 Commercial Travel to and From Continental United States.
- 59-, 95-, 96-Series Air Transportation in General.
- 725-768 Supply and Maintenance Support Provided by Army Aircraft Field Maintenance Shops.
- 750-22 Technical Assistance Program.
- 750-712 Modification of Army Aircraft and Transportation Air Items.
- 750-713 Repair and Overhaul of Army Aircraft.

b. Special Regulations

- 310-30-15 Organization and Equipment Authorization Tables; Personnel.

c. Field Manuals

- 1-100 Army Aviation.
- 57-10 Army Forces in Joint Airborne Operations.
- 57-35 Airmobile Operations.
- 101-10 Staff Officers' Field Manual.

d. Technical Manuals

- 1-215 Attitude Instrument Flying.
- 1-250 Principles of Fixed-Wing Flight.
- 1-260 Principles of Rotary-Wing Flight.
- 5-251 Army Airfields and Heliports.
- 38-250 Packaging and Handling of Dangerous Materials for Transportation by Military Aircraft.
- 55-401 Army Aircraft Field Maintenance Shop and Supply Operations.
- 55-450-Series Air Transport of Supplies and Equipment.
- 57-210 Air Movement of Troops and Equipment.

e. Technical Bulletins

- AVN 2 Recommended Fuels, Engine and Transmission Oils for Army Aircraft.
- AVN 7 Painting and Marking of Army Aircraft.
- AVN 23-5-Series Unsatisfactory Report Digest.
- AVN 23-8 Reporting Criteria and Instructions for Processing Damaged or Deteriorated Aircraft.
- AVN 24-1 Engine Detonation and/or Pre-Ignition.

f. Supply Bulletins

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- 1-2 Army Aircraft Maintenance Man-Hour Factors and Availability Norms.
- 1-15-8 Expendability of Transportation Air Items.
- 1-15-9 Army Aircraft Modification Kits.

g. Tables of Organization and Equipment

- 55-56 Headquarters and Headquarters Detachment, Transportation Transport Aircraft Battalion.
- 55-57 Transportation Light Helicopter Company.
- 55-58 Transportation Medium Helicopter Company.
- 55-79 Infantry Division Transportation Aircraft Maintenance Detachment, or Armored Division Transportation Aircraft Maintenance Detachment.
- 55-89 Transportation Aircraft Maintenance Company, Armored, Infantry, or Mechanized Division Maintenance Battalion.
- 55-99 Transportation Aircraft Maintenance Company, Airborne Division Maintenance Battalion.
- 55-456 Headquarters and Headquarters Detachment, Transportation Aircraft Maintenance and Supply Battalion.
- 55-457 Transportation Aircraft Direct Support Company.
- 55-458 Transportation Army Aircraft Heavy Maintenance and Supply Company.
- 55-468 Transportation Transport Aircraft Direct Support Company.
- 55-469 Transportation Light Transport Helicopter Direct Support Maintenance and Supply Company.
- 55-500 Transportation Service Organization.

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- 55-15 U.S. Army Transportation Aircraft Test and Support Activity.
- 55-84 Army Aircraft Field Maintenance Shops.

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- 58-30 Transportation of Dependent School Children.
- 385-55 Preventive of Army Motor Vehicle Accidents.
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 - 350-355-1 Traffic Management.
 - 705-325-1 Electrical Systems in Motor Vehicles.
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 - 19-25 Military Police Traffic Control.
 - 20-32 Land Mine Warfare.
 - 21-60 Visual Signals.
 - 25-10 Motor Transportation, Operations.
 - 31-70 Basic Cold Weather Manual.
 - 55-31 Motor Transport Service in Theaters of Operation.
 - 55-37 Infantry Division, Transportation Battalion and Transportation Tactical Carrier Units.
 - 101-5 Staff Officers' Field Manual.
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 - 9-2800 Military Vehicles.
 - 38-750 The Army Equipment Record System and Procedures.
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 - 55-11 Headquarters and Headquarters Company, Transportation Motor Transport Command.
 - 55-12 Headquarters and Headquarters Detachment, Transportation Truck Group.
 - 55-16 Headquarters and Headquarters Detachment, Transportation Truck Battalion.
 - 55-17 Transportation Light Truck Company.
 - 55-18 Transportation Medium Truck Company.
 - 55-19 Transportation Car Company, Army, Theater Communications Zone or Airborne Corps.
 - 55-27 Transportation Cargo Carrier Company (Tracked).
 - 55-28 Transportation Heavy Truck Company.
- 55-46 Headquarters and Headquarters Detachment, Transportation Tactical Carrier Battalion.
- 55-47 Transportation Tactical Carrier Company.
- 55-75 Infantry Division Transportation Battalion.
- 55-76 Headquarters and Headquarters Company, Infantry Division Transportation Battalion.
- 55-77 Truck Transport Company, Infantry Division Transportation Battalion.
- 55-78 Armored Carrier Company, Infantry Division Transportation Battalion.
- 55-87 Transportation Motor Transport Company, Armored and Mechanical Division Supply and Transport Battalion.
- 55-88 Transportation Motor Transport Company, Infantry Division Supply and Transport Battalion.
- 55-97 Transportation Motor Transport Company, Airborne Division Supply and Transport Battalion.
- 55-500 Transportation Service Organization.
- h. Department of the Army Forms*
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 - 1249 Bridge Reconnaissance Report.
 - 1250 Tunnel Reconnaissance Report.
 - 1251 Ford Reconnaissance Report.
 - 1252 Ferry Reconnaissance Report.
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 - 2401 Organizational Control Record for Equipment.
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 - 55-125 Troop Train Emergency Supply Points.
 - 55-255 Railroad Equipment.
 - 55-650 Railroads.
- b. Special Regulations*
 - 55-135-5 Inspection of Dining Cars on Troop Trains.
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 - 55-21 Rail Transportation (Higher Units).
 - 55-22 Transportation Railway Operating Battalion.
- d. Technical Manuals*
 - 55-200 Railway Operating Rules.

- 55-201 Operation, Inspection, and Maintenance of Steam Locomotives and Locomotive Cranes.
 - 55-202 Fundamentals of Operation and Maintenance of Diesel-Electric Locomotives.
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 - 55-289 Operation of Railroads: Standard Painting, Lettering, and Numbering of Railroad Equipment.
- e. Supply Bulletins*
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 - 55-35 Return of Army Rapid Service Items.
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 - 55-217 Transportation Electric Power Transmission Company.
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 - 55-227 Railway Engineering Company, Transportation Railway Operating Battalion.
 - 55-228 Railway Equipment Company, Transportation Railway Operating Battalion.
 - 55-229 Train Operating Company, Transportation Railway Operation Battalion.
 - 55-235 Transportation Railway Shop Battalion.
 - 55-236 Headquarters and Headquarters Company, Transportation Railway Shop Battalion.
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- 55-107 Policy Governing Transportation of Passengers Aboard Vessels of Military Sea Transportation Service.
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g. Tables of Organization and Equipment

- 55-111 Headquarters and Headquarters Company, Terminal Command C.
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- 55-117 Transportation Terminal Service Company.
- 55-121 Headquarters and Headquarters Company, Terminal Command B.
- 55-126 Headquarters and Headquarters Company, Transportation Boat Battalion.
- 55-127 Transportation Light Boat Company.
- 55-128 Transportation Medium Boat Company.
- 55-129 Transportation Heavy Boat Company.
- 55-131 Headquarters and Headquarters Company, Terminal Command A.
- 55-137 Transportation Amphibious Truck Company.
- 55-138 Transportation Light Amphibian Company.
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- 55-11 Agreements Between Army and Air Force.
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- 310-22 Military Publications: Index of Supply Manuals, Transportation Corps.
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- 21-10 Military Sanitation.
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- 21-30 Military Symbols.
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APPENDIX II

ABBREVIATIONS

(Any abbreviation marked with an asterisk is not authorized for electrically transmitted messages.)

Abbreviations	Meaning	Abbreviations	Meaning
*A	Army	apers	antipersonnel
AA	arrival angle	APMA	advance payment of mileage authorized
AACFT	Army aircraft	APMALTA	advance payment of monetary allowance in lieu of transportation is authorized
AAM	air-to-air missile	APO	Army Post Office; Air Post Office
AAOD	Army Aviation Operating Detachment	APOD	Aerial Port of Debarkation
AAR	Association of American Railroads; Army Area Representative	APOE	Aerial Port of Embarkation
AATOC	Airhead Air Traffic Coordination Center	app	appendix; apprehend
AAVN	Army Aviation	APRI	air priority
AB	air base	APTDA	advance payment of travel per diem authorized
abn	airborne	ARSR	air route surveillance radar
ACC	Air Control Center	ARTC	Air Route Traffic Control
acft	aircraft	ARTCC	Air Route Traffic Control Center
ACOG	aircraft on ground	asg	assign; assigned
ACPATT	all commands through which this shipment passes will process these personnel (this individual) as attached	ASOC	Air Support Operations Center
ACT	air control team	ASP	ammunition supply point
actv	activity; activate	ASR	available supply rate
ACW	aircraft control and warning	ASUPP	air supply
ADEP	air depot	at	antitank
ADLOG	advance logistical command	ATA	actual time of arrival
admin	administrate	ATCC	Air Traffic Control Center; Atlantic Division Transport Control Center (Hq)
ADSHIPDA	advise shipping data	atch	attach
ADSHPDAT	advise shipping date	ATCO	Air Traffic Coordinating Officer
aero	aeronautics	ATCS	Air Traffic Communications Station
afld	airfield	ATD	actual time of departure
AH	airfield heliport	ATERN	air terminal
ahd	airhead	ATMC	Air Transport Movement Control Center
al	airlift	ATO	Aircraft Transfer Order
ALCO	Airlift Coordinating Office (r)	ATR	Air Traffic Regulations
ALG	advance landing ground	autmv	automotive
alt	altitude	auto	automatic
altn	alternate; alternative	aux	auxiliary
alw	allowance	aval	available
amb	ambulance	AVGAS	aviation gasoline
AMD	air movement designator	AVIONICS	aviation electronics
AMEDS	Army Medical Service	AVLUB	aviation lubricant
AMIS	Air Movements Information Section	avn	aviation
amph	amphibious	AVOIL	aviation oil
AMTK	amphibious tank	AWS	Air Weather Service
AMTRAC	amphibious tractor	az	azimuth
AMVM	administrative motor vehicle management	bag	baggage
anx	annex	BALOG	base logistical command
AOC	Air Operations Center	BARC	barge, amphibious, resupply, cargo
AOCM	aircraft out of commission for maintenance	bdry	boundary
AOR	Advance List of Oversea-Returnees for Reassignment	BG	beach group, battle group
APC	armored personnel carrier	bhd	beachhead
		BMU	beachmaster unit
		bn	battalion

Abbreviations	Meaning
BP	basic pay; base point; beach party
brg	bearing; bridge
bt	boat
BTO	bombing through overcase; branch transportation office (r)
btry	battery
BTW	boat wave
BW	biological warfare
CA-A	compound, antifreeze, arctic
CAFM	Commercial Air Freight Movement
CAM	commercial air movement number
cam	camouflage; camouflaged
cap	capacity
CARP	Computed Air Release Point
carr	carrier
cbn	carbine
CBR	chemical, biological, and radiological warfare
CBTI	combat intelligence
CFM	Contingency for Movement
cft	craft
CG	commanding general
ego	cargo
char	characteristics
CHB	Cargo Handling Battalion
CHE	cargo handling equipment
cir	circular
cl	class; carload
clnc	clearance
clr	clearing
cmbt	combat
cmdty	commodity
cml	chemical
COE	cab over engine
CofT	Chief of Transportation
coll	collect
coln	column
COMATS	Commander Military Air Transport Service
comb	combine
comd	command
coml	commercial
comm	communication
COMMZ	communications zone
COMSTS	Commander Military Sea Transportation Service
con	conversation; consul, consulate; control; controlled
CONEX	Reusable shipping container operated by the Joint Army and Air Force Conex Control Agency for worldwide surface movement of suitable military supplies and equipment
consol	consolidate
const	construct; construction; constructed
CONUS	Continental United States
cor	corridor
CP	command post; cost and performance
cpbl	capable

Abbreviations	Meaning
cr	crossroads
crypto	cryptography; cryptographic
CS	current series; close support; contract surgeon
CTB	Commercial Traffic Bulletin
CTE	Command Task Element
CVEH	combat vehicle
CW	continuous wave; chemical warfare
CWM	commercial water movement number
CZ	Combat Zone
d	diesel
DAATCO	Department of the Army Air Traffic Coordinating Officer
DALT	drop altitude
DANC	decontaminating agent, noncorrosive
DAO	Division Ammunition Officer
DAS	direct automotive support
DASC	direct air support center
DBP	drawbar pull
DCSLOG	Deputy Chief of Staff for Logistics
debk	debark
decon	decontaminate
def	defend; defended; defense; defensive
dep	depot
dest	destination; destroy
dir	direct; directed; direction
DIR	depot inspection and repair
dis	distant
disem	disseminate; dissemination
disemb	disembark
DLCC	Division Logistics Control Center
DLOC	Division Logistical Operation Center
docu	document
DOD	Department of Defense
DODHGCSO	Department of Defense Household Goods Commercial Storage Office
DODHGFO	Department of Defense Household Goods Field Office
DOFS	day of supply
DP	displaced person; by direction of the President; delivery point
dptrk	dumptruck
DR	dead reckoning
DS	direct support; directing staff
DSA	Defense Supply Agency
DSAS	Direct Support Aviation Section
dsmtd	dismounted
DTMS	Defense Traffic Management Service
DTO	district transportation officer
DUKW	amphibious truck, 2½-ton, cargo
dvr	driver
DW	dead weight
dy	duty
I/Z	drop zone
EA	enemy aircraft
EAT	earliest arriving time

<i>Abbreviations</i>	<i>Meaning</i>
EC	Emergency Capability
ech	echelon
EDD	estimated delivery date
EDP	equipment deadlined for parts; electronic data processing
EEI	essential elements of information
elm	element
EM	enlisted man (men); Education Manual
emb	embark; embarked; embarkation
en	enemy
eng	engine
enr	en route
ENRFOSCOMD	en route this station from oversea command
EP	entrucking point
est	estimate; estimated; estimation
ETA	estimated time of arrival
ETD	estimated time of departure
ETDP	Emergency Traffic Disposition Plan
ETE	estimated time en route
ETR	estimated time of return; Export Traffic Release
ETS	expiration term of service
evac	evacuate; evacuated; evacuation
EXTAL	extra time allowance
FAS	free alongside ship
FASO	forward airfield supply organization
FIO	Free In and Out
FLDO	field officer
FLDTNS	field trains
flt	flight
Fltbrg	floatbridge
FOA	Free of Address
FOB	Free on Board
FSO	Fuel Supply Office
FTD	Freight Traffic Division
FTRAC	full-tracked vehicle
fus	fuselage
FW	fixed wing
fxd	fixed
gal	gallon
gas	gasoline
GCA	ground controlled approach
GCM	general court-martial
GED	gas engine driven
gnd	ground
GNP	chemical agent, nonpersistent
GP	general purpose
gp	group
GPV	general purpose vehicle
gd	guard
GS	General Staff; general service
GTA	graphic training aid
GTAV	general transport administrative vehicle
HAMD	Helicopter Ambulance Medical Detachment
har	harbor
HARCFT	harbor craft
HBS	harbor boat service

<i>Abbreviations</i>	<i>Meaning</i>
HD	Honorable Discharge; harbor defense
HDC	Helicopter Direction Center; harbor defense command
hdlg	handling
HE	high explosive
HECP	Harbor Entrance Control Post
HECVES	Harbor Entrance Control Vessel
hel	helicopter
HELITEAM	helicopter team
HF	high frequency; harassing fire
HHG	household goods
HOA	heavy observation aircraft
how	howitzer
HRAT	Hampton Roads Army Terminal
HRP	holding and reconsignment point; highway regulation point
HS	hardstanding; high school
HV	high velocity
hv	heavy
hyd	hydraulic
hydro	hydrographic
ICC	Interstate Commerce Commission
ICW	intercoastal waterway
IFR	Instrument Flight Rules
ILS	instrument landing system
init	initial
insp	inspect
instl	installation; install
instr	instruct; instructor; instruction; instructed
intel	intelligence
intmed	intermediate
intns	in transit
IR	instrument reading
IROAN	inspect and repair only as necessary
iss	issue
ITS	Intersectional Transportation Service
IWT	Inland Waterway Transport
IWW	inland waterway
JANAST	Joint Army-Navy-Air Force Sea Transportation Message
JANIS	Joint Army-Navy Intelligence Study
JATO	Jet-assisted takeoff
JATS	Joint Air Transportation Service
JCCA	Joint CONEX Control Agency
JCS	Joint Chiefs of Staff
jct	junction
JMTB	Joint Military Transportation Board
JOSPRO	Joint Overseas Shipping Procedure
JTF	Joint Task Force
LA	low altitude; letter of activation
LANCRAB	landing craft and bases
LARC	lighter, amphibious, resupply, cargo
LC	line of contact; launching control
LCAVAT	landing craft and amphibious vehicle assignment table
lchr	launcher

<i>Abbreviations</i>	<i>Meaning</i>
LCL.....	less than carload lot
LCM.....	landing craft, mechanized
LCVP.....	landing craft, vehicle, personnel
LD.....	line of duty; line of departure
ldg.....	landing
LE.....	light equipment; low explosive
ln.....	liaison
LO.....	lubrication order; letter order; liaison officer; local oscillator
LOA.....	light observation aircraft; leave of absence
loc.....	locate; locating; located; location; locality
loco.....	locomotive
log.....	logistics; logistical
LOGEX.....	logistical exercise
LOTS.....	logistics over-the-shore operations
LSE.....	landing signal, enlisted
LSD.....	Landing Ship, Dock
LSO.....	Landing Signal Officer
LST.....	Landing Ship, Tank
LTD.....	less than truckload
LTON.....	long ton
ltr.....	letter
LVD.....	low velocity drop
LVTP.....	landing vehicle, tracked, personnel
LWB.....	long wheelbase
LWL.....	load waterline
MA.....	marshaling area; machine account- ant; military attache
MAAG.....	Military Assistance Advisory Group
MAC.....	Mean Aerodynamic Chord; Main- tenance Allocation Chart
mach.....	machine; machinist
MAIN.....	Military Authorization Identifica- tion Number
MAM.....	military air movement number
man.....	manifest
MANDR.....	maintenance and repairs
MAP.....	Military Assistance Program
mat.....	materiel; material
MATS.....	Military Air Transport Service
mbL.....	mobile
MCC.....	Movement Control Center; mili- tary Coordinating Committee
MD.....	Movement Directive
MDHTSMAGEJTR.....	Movement of dependents and household goods to temporary station(s) not authorized at Government expense, except as prescribed in JTR, chapter 8
me.....	multiengine
mech.....	mechanic; mechanical; mechanized
MEDP.....	medium port
mg.....	machinegun
MHE.....	materials handling equipment
MM.....	Motor Maintenance Aptitude Area; Missile Master
MO.....	movement orders
MOGAS.....	motor gasoline
MOS.....	military occupational specialty
MOT.....	month of travel

<i>Abbreviations</i>	<i>Meaning</i>
mov.....	movement
MPH.....	miles per hour
msg.....	message
MSR.....	main supply route
MSTS.....	Military Sea Transportation Serv- ice
MSTSO.....	Military Sea Transportation Serv- ice Office
MT.....	motor transport; mechanical trans- port; megaton
MTCC.....	MATS Transport Control Center (Hq)
mtd.....	mounted
MTON.....	measurement ton
mtr.....	motor
mtrel.....	motorcycle
MVD.....	Army Motor Vehicle Driver Selec- tion Battery
MWO.....	Modification Work Order
NA.....	not applicable
NASA.....	National Aeronautics and Space Administration
NATO.....	North Atlantic Treaty Organiza- tion
nav.....	navigate; naval
NAVCM.....	navigation countermeasures and deception
NCO.....	noncommissioned officer
NCS.....	net control station
NFS.....	not on flying status
ni.....	night
NLF.....	nearest landing field
NLG.....	nose landing gear
NLT.....	not later than
NOART.....	New Orleans Army Terminal
nonptbl.....	nonportable
NRA.....	no repair action; National Rifle Association; nonregistered ac- countable
NTI.....	no travel involved
*O.....	order; office
obs.....	obstacle
OIC.....	officer-in-charge (of)
OL.....	operation location
OMS.....	organizational maintenance shop
op.....	operate; operated; operational; operation; operator
OP.....	observation post
ord.....	ordnance
org.....	organization; organize; organized
OSPE.....	organizational spare parts and equipment
PC.....	port call; purchasing and con- tracting
PD.....	per diem; full stop/period
plat.....	platoon
PLL.....	prescribed load list
POD.....	port of debarkation
POE.....	port of embarkation
POL.....	petroleum, oil, and lubricants
POLIS.....	Petroleum Intersectional Service
POM.....	preparation for oversea movement (units)

<i>Abbreviations</i>	<i>Meaning</i>
POR.....	preparation of replacements for oversea movement
pos.....	position
pri.....	priority
proc.....	process, procure
PSANDT.....	pay, subsistence, and transporta- tion
pt.....	point
ptbl.....	portable
ptl.....	patrol
pty.....	party
PW.....	prisoner of war; public works; pulse width
RADIAC.....	radiation, detection, indication, and computation
RADLWAR.....	radiological warfare
RASO.....	Rear Airfield Supply Organization
rawa.....	rail-water
rawara.....	rail-water-rail
RB.....	road bend; rigid boat
rd.....	road; round
RD.....	readiness date; research and de- velopment; required date
RDD.....	required delivery date
recon.....	reconnaissance; reconnoiter
rein.....	reinforce
rep.....	repair; represent; represented; re- presentative
REQSI.....	request shipping instructions
res.....	reserve(s)
resc.....	rescind
RFA.....	Reserve Forces Act, relieved from assigned
rfl.....	refuel
rh.....	railhead
RJ.....	road junction
rkt.....	rocket
rnwy.....	runway
ROAD.....	Reorganization Objective Army Divisions
ROCID.....	reorganization of the current in- fantry division release point (ground traffic); retained per- sonnel
RS.....	report of survey; road space; re- gulating station
rsq.....	rescue
RTC.....	replacement training center
RTO.....	rail transportation office(r); rail- way traffic officer
RW.....	rotary wing
rw.....	railway
SCM.....	summary court-martial; sender's composition message
SDC.....	shipment detail card
SE.....	single engine
sec.....	section
SHAPE.....	Supreme Headquarters, Allied Powers Europe
SHIPDA.....	shipping data
SHIPDTO.....	ship on depot transfer order
SHIPGO.....	shipping order
SHIPIM.....	ship immediately

<i>Abbreviations</i>	<i>Meaning</i>
SHIPREQ.....	ship to apply on requisition
sho.....	shore
shpmt.....	shipment
shpsd.....	shipside
sig.....	signal; signaller, signalman
sit.....	situation
scd.....	schedule
SLA.....	supply loading airfield
smb.....	semimobile
SO.....	shipment order; Special Orders; stockage objectives
SOI.....	signal operations instructions
SOP.....	standing operating procedures
SP.....	self-propelled; start point; shore party; shore police
S&P.....	stake and platform vehicle
SPCM.....	special court-martial
spd.....	speed
SPE.....	special purpose equipment
SPM.....	self-propelled mount
spt.....	support
SPV.....	special purpose vehicles
SSI.....	standing signal instructions
sta.....	station; status
STANAG.....	standardization agreement
std.....	standard; standing
stf.....	staff
STGAR.....	staging area
STGB.....	staging base
stlr.....	semitrailer
STOL.....	short takeoff and landing
STON.....	short ton
stor.....	storage
str.....	strength
subor.....	subordinate
SUNEC.....	supply units, Northeast Command
sup.....	supply; supplied
SUPPT.....	supply point
svc.....	service; serviced; servicing
SWB.....	short wheelbase
swbd.....	switchboard
T.....	ton
TA.....	table of allowance; target area; time and attendance
TAAM.....	Transportation Army Aviation Maintenance
TAAS.....	Transportation Army Aircraft Supply
TAD.....	tactical air direction
TADC.....	Tactical Air Direction Center
TAF.....	Tactical Air Force
TAHQ.....	theater army headquarters
TALOG.....	theater army logistical command
TASS.....	Tactical Air Support Section
TAT.....	to accompany troops
TATSA.....	Transportation Aviation Test and Support
TB.....	technical bulletin; troop basis; tuberculosis
TBAWRBA.....	travel by military aircraft, military and/or Naval water carrier, commercial rail and/or bus is authorized

<i>Abbreviations</i>	<i>Meaning</i>
TBGAA.....	travel by Government automobile authorized
TBMAA.....	travel by military aircraft authorized
TCC.....	transportation control card; Transport Control Center; Troop Carrier Command
TCF.....	troop carrier forces
TCP.....	traffic control post
TCR.....	Transportation Corps release
TCSMC.....	Transportation Corps Supply and Maintenance Command
TCTC.....	Transportation Corps Technical Committee
TCTM.....	Aircraft Time Compliance Technical Manuals
TCV.....	troop carrying vehicle
TDHHG.....	For travel of dependents authorized transportation of household goods including packing and crating, and unpacking and uncrating
TDN.....	travel as directed is necessary in the military service
tfc.....	traffic
THM.....	transport helicopter maintenance
THQ.....	theater headquarters
tk.....	tank
tl.....	truckload
tlr.....	trailer
TMAO.....	troop movement assignment order
TMDAG.....	this mode of transportation has been determined to be more advantageous to the Government
tml.....	terminal
TMO.....	Transportation Movements Office (r); Total Material Objective
tn.....	train
TOE.....	table of organization and equipment; term of enlistment
TOS.....	type of shipment
TPA.....	travel by privately owned conveyance authorized
TR.....	Transportation Request
trac.....	tractor; tracer
tracdr.....	tractor-drawn
tran.....	transient
trans.....	transport
TRC.....	transportation railway command; type requisition code
trk.....	truck
trkdr.....	truck-drawn
trkhd.....	truckhead
TROB.....	transportation railway operating battalion
trp.....	troop
TRS.....	Transportation Railway Service
TRSB.....	transportation railway shop battalion
TS.....	transit storage; terminal service;

TOP SECRET

<i>Abbreviations</i>	<i>Meaning</i>
TSD.....	theater shipping document
TSMC.....	Transportation Supply and Maintenance Command
TSO.....	Transportation Supply Officer
TT.....	teletypewriter; technical test; troop test
TTA.....	travel time authorized
tvL.....	travel
TVLADVP.....	travel advance payment (TDY)
TVLALWADV.....	travel allowance advance (in PCS)
TVLALWS.....	travel allowance on separation
TWT.....	travel with troops
twy.....	taxiway
*U.....	unit
U.....	utility type aircraft
UC.....	under construction
UCMJ.....	Uniform Code of Military Justice
USAAFIO.....	United States Army Aviation Flight Information Office
USAAVNC.....	United States Army Aviation Center
USAAVNS.....	United States Army Aviation School
USAMDLC.....	United States Army Materiel Development and Logistic Command
USAPHTS.....	United States Army Primary Helicopter Training School
USAR.....	United States Army, Reserve
USAREUR.....	United States Army, Europe
USARPAC.....	United States Army, Pacific
USATATSA.....	United States Army Transportation Aircraft Test and Support Activity
USATMC.....	United States Army Transportation Materiel Command
USATRECOM.....	United States Army Transportation Research Command
USATSCH.....	United States Army Transportation School
USATTC.....	United States Army Transportation Training Command
USSR.....	Union of Soviet Socialist Republics
util.....	utility
VCP.....	vehicle collecting point
veh.....	vehicle
vert.....	vertical
ves.....	vessel
vet.....	veterinary; veteran
VFR.....	visual flight rules
VHA.....	very high altitude
VLA.....	very low altitude
VPM.....	vehicles per mile
VSD.....	Vendor's Shipping Document
VSTOL.....	vertical and short takeoff landing
VTOL.....	vertical takeoff landing
W.....	wheel
WAB.....	when authorized by
wea.....	weather
WFCMV.....	wheeled fuel-consuming motor vehicle
wg.....	wing

<i>Abbreviations</i>	<i>Meaning</i>
whs.....	warehouse
wkr.....	wrecker
wng.....	warning
WOWN.....	without winch
wpn.....	weapon

<i>Abbreviations</i>	<i>Meaning</i>
WS.....	water supply
WSP.....	water supply point
WWN.....	with winch
xpd.....	expedite
xplt.....	exploit

APPENDIX III **MAP SYMBOLS**

a. Air. 1/

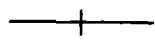
Aircraft:	
Damaged	
Dummy	
Heavy maintenance and supply company	 HMS
Maintenance and supply units	
Svc Plat, 508th Trans Transport Hel Maint Co	SVC  508 THM
509th Trans Acft Direct Support Maint Co	 509 DS
510th Trans General Support Acft Supply Co	 510 GS
Airfield:	
Advanced	 Adv
Dummy	
Under construction	 UC
Airport, commercial or municipal	
Airship	
Airstrip for Army aviation units	
Aviation Army units	

1/ All symbols refer to piston engine aircraft. If a symbol having a propeller refers specifically to Army aviation, the propeller is black.

Helicopter: _____ 

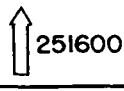
Landing area, or heliport _____ 

b. Motor Transport.

Boundary between two sections of road _____ 

Convoy (Arrow indicates direction; point of arrow indicates position of

head of convoy; figures immediately adjacent to arrow indicate time

at that position.) _____ 

Destination point _____ 

Highway regulating point _____ 

Impassable section of road _____ 

Light line (The line beyond which exposed lights are prohibited) _____ 

Main supply route _____ 

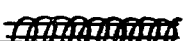
Markers:

Road, national and state, respectively (U.S.) _____ 

Route, military _____ 

Route:

Dispatch, operated by schedule system _____ 

Express _____ 

Reserved, can be used by specified traffic only _____ 

Start point _____ 

Traffic: _____ 

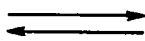
Headquarters _____

One-way _____ 

One-way, alternate _____ 

Post _____ 

Rotary _____ 

Two-way _____ 

Turnaround location _____ 

Vehicle:

Armored _____ 

Cargo-carrying _____ 

Operational _____ 

Personnel-carrying _____ 

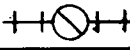
Tracked _____ 

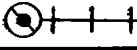
Wheeled _____ 

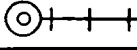
c. Rail.

Coaling station, Transportation Railway Service _____ 

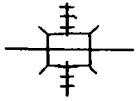
Engine terminal:

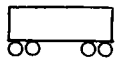
Turntable alone _____ 

With turntable (roundhouse) _____ 

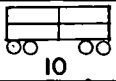
Without turntable (engine sheds) _____ 

Railroad:

Beneath road _____ 

Car _____ 

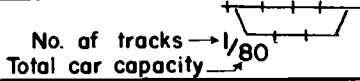
Grade crossing _____ 

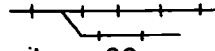
Hospital train (Numeral indicates number of cars) _____ 

Locomotive _____ 

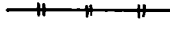
Locomotive and train of 14 cars _____ 

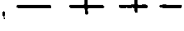
Over road _____ 

Passing siding _____ 

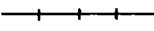
Spur or siding _____ 

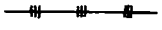
Track:

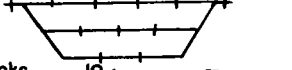
Double _____ 

Nonoperational, single-track _____ 

Pan _____ 

Single _____ 

Three _____ 

Yard (Sidings and yards are drawn on proper side of the main track.) _____ 

Railway:

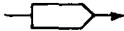
Vehicle _____ 

— d. Terminal and Water Transport.

Amphibious, Cargo _____ 

Debarkation or Embarkation point, water _____ 

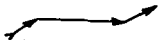
Landing:

Craft or ship _____ 

Vehicle, tracked _____ 

Vehicle, tracked, armored _____ 

Leader gear (Energized cable to aid vessels through free passage

In marine mine fields. Show exact location on chart.) _____ 

Marine:

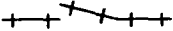
Mines, controlled:

19-mine group, buoyant _____ 

13-mine group, ground _____ 

(Length of either mine group is 1,800 feet, and symbol is drawn to scale, with upper edge seaward.)

Nets:

Antisubmarine, with gate _____ 

Torpedo, with gate _____ 

Sono-buoys _____ 

Terminal command:

A (3d)



3 Term Cmd. A

B (4th)



4 Term Cmd. B

C (5th)



5 Term Cmd. C

Terminal, water



W Term

Tower, water, elevated



Transportation Terminal Battalion (12th Term)



12 Term

Transportation Terminal Service Company (194th)



194 Term Svc

Vehicle:

Cargo, amphibious



Truck, amphibious, wheeled



3. Miscellaneous.

Booby trap



Boundary line:

Advance or base logistical command



Area command



Battalion



Brigade



Company, Battery, or equivalent unit



Corps

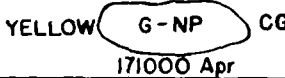


High wire fence _____ 

Low wire fence _____ 

Single barbed wire fence _____ 

Gas area to be avoided (Show agent and date fired.) _____ 

Gas area to be gassed, nonpersistent (Show agent, time, and date
to be fired.) _____ 

Inundations _____ 

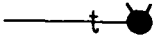
Mine:

Antitank _____ 

Antipersonnel _____ 

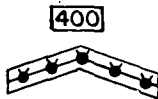
Antitank, baoby-trapped _____ 

Antitank, double _____ 

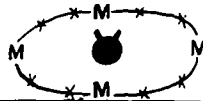
Trip wire type of antipersonnel mine _____ 

Mine belt (Numerals in rectangle indicate number of mines in

belt; Type of mines shown by symbols;

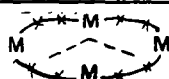
boundaries drawn to scale indicate actual extent of belt.) _____ 

Minefield:

Antipersonnel, or boundary thereof, marked, fenced _____ 

Antitank, or boundary thereof, marked, fenced _____ 

Antitank with antipersonnel mines, marked, fenced _____ 

Dummy, marked, fenced _____ 

Division _____ XX

Group, battle group or regiment _____ III

Platoon, detachment _____ ● ● ●

Section _____ ● ●

Squad _____ ●

Theater administrative zone or theater army logistical command _____ ○ ○ ○ ○

Bridge: _____) {

Movable _____ — } • { —

Control stations:

Consolidating station _____ ⊗ C Sta

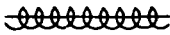
Holding and reconsignment point _____ ⊗ HRP

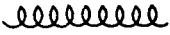
Release or regulating point _____ RP

Culvert _____ —)(—

Entanglements:

Barbed wire, general (Depth of wire in feet may be indicated.) _____ XXXXXX

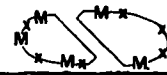
Concertina, multiple _____ 

Concertina, single _____ 

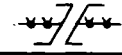
Double-apron fence _____ — XXXXX —

Double barbed wire fence _____ ** — ** — **

Gap _____



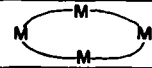
Gap, through single-string antipersonnel mines _____



Unconfirmed boundary of _____



Unfenced, or boundary thereof _____



Mines:

Antipersonnel, string of _____



Antitank, single string of _____



Obstacle:

General symbols:

Completed _____



Prepared but passable _____



Proposed _____



Specific obstacles:

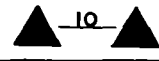
Fixed _____



Fixed, prefabricated _____



Fixed, prefabricated (In line; numeral indicates number of
obstacles between accurately located points.) _____



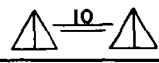
Movable _____



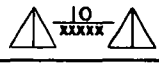
Movable, prefabricated _____



Movable, prefabricated (Numeral indicates number of obstacles
in each row; lines indicate number of rows.) _____



Movable, prefabricated (When used with wire or mines, add
appropriate symbol.) _____



POL facilities _____



POL and minor maintenance facilities _____



Smoke: area to be blanketed by smoke
(Show type of screen, time, date, and method.) _____



Snow:

Carrier, cargo, over-snow _____



Carrier, personnel, over-snow _____



Over snow _____



Staging area _____



Supply installations:

Classes of:

Class I (rations) _____



Class II ^L_____

Class III (POL) _____



Class IIIA (aviation POL) _____



Class IV ^L_____

Class V (ammunition, conventional types) _____



Class V (chemical only) _____



Occupied _____



Unoccupied _____



^L/ Class II and Class IV are shown by using the symbol for the service or activity which is responsible for the supply of items of these classes of supply.

Transportation Movement office _____  TMO

Tunnel _____ 

Unit:

Logistical Command _____ 

Transportation _____ 

Vehicle:

Shop truck _____ 

Skid or sled _____ 

INDEX

	Paragraph	Page
AAR.....	4.14, 4.16	141, 147
Abbreviations (<i>see also</i> Classification; Designator; Symbols).....	App. II	390
Address marking.....	7.17	285
Administrative:		
Loading.....	5.35d	219
Order.....	6.3, 6.4	244, 246
Aeration, water.....	7.42e	334
Aerial delivery.....	2.19	38
A-frame.....	3.44, 7.44, 7.45	116, 336
After perpendicular.....	5.33a	209
AGC vessel.....	5.12	180
Aid station.....	7.23	295
Air (<i>see also</i> Aircraft; Aviation):		
Attack, defense against.....	3.8, 4.20, 7.24	53, 157, 297
Compressor.....	4.23	164
Density.....	2.2b	4
Force aircraft.....	2.5b, 2.6, 2.21, 7.70-7.72	29, 31, 38, 373
Movements.....	2.7, 2.11, 2.23, 7.17a	33, 35, 38, 285
Priority.....	2.7a	33
Shipment.....	7.17	285
SOP.....	2.8	34
Temperature.....	2.2b	4
Terminal.....	2.7a, b, 2.21, 7.17	33, 38, 285
Airburst, nuclear.....	7.24a	297
Air-cooled engine.....	2.2c	5
Aircraft (<i>see also</i> Airplane; Helicopter).....	7.10, 7.70-7.72	281, 373
Availability.....	2.23c, 2.24	39, 40
Balance.....	2.9, 2.10	34, 35
Carrier.....	5.14, 5.16	187
Fuel (<i>see also</i> POL).....	3.48, 7.31, 7.32, 7.54	120, 324, 351
Landing site.....	2.21	38
Loading.....	2.3, 2.5b, 2.10, 2.13-2.16, 2.20, 2.21, 7.70-7.72	22, 29, 35, 38, 373
Maintenance.....	2.23-2.26	38
Mission planning.....	2.2	4
Performance.....	2.2	4
Supply.....	2.1, 2.7b, 7.1, 7.31, 7.32, 7.54	3, 33, 261, 324, 351
Transportability.....	2.2f, 7.70-7.72	10, 373
Units.....	2.1, 7.70-7.72	3, 373
Airfield.....	2.21	38
Air-ground communication.....	3.16, 7.21	73, 291
Airplane (<i>see also</i> Aircraft; Helicopter).....	2.1, 2.2-2.6, 2.14, 2.16, 2.20b, 2.21, 2.24, 7.10, 7.70-7.72	3, 4, 36, 37, 38, 40, 281, 373
AKA vessel.....	5.12	180
Alcohol.....	7.11	281
Alongside discharge.....	5.25, 5.29	200, 205
Alphabet, phonetic.....	7.20	291
Ambulance:		
Car.....	4.3, 7.4	127, 262
Train.....	4.1	124
Vehicle.....	3.2, 3.16g	44, 73

	Paragraph	Page
Ammunition (<i>see also</i> Missile)	3.36, 4.9, 4.16, 4.17, 5.19b, 5.26b, 5.35d, 7.31, 7.32b, 7.38c, 7.54b, 7.70	95, 133, 147, 149, 196, 203, 219, 324, 325, 329, 351, 373
Amphibian units	5.1, 5.2	170, 173
Amphibious (<i>see also</i> Landing Craft; Lighter):		
Craft	5.1, 5.11, 5.12, 5.19, 5.20, 5.36, 7.4	170, 180, 195, 197, 220, 262
Operations	5.1, 5.35, 5.39	170, 218, 222
Truck company	5.1, 5.2, 7.70-7.72	170, 173, 373
Anchorage	5.25, 5.29b	200, 205
Anchoring methods	3.43	115
Angular conversion	7.47d	340
Animal	4.4, 7.2	130, 261
Annealed wire	7.33	328
Anticipated tonnage	5.24	200
Antifreeze	7.9d, 7.11	280, 281
APA vessel	5.12	180
APD vessel	5.12	180
Armored vehicle. (<i>See</i> Tank, tracked.)		
Arc of circle	4.28, 7.58	167, 357
Arctic data (<i>see also</i> Snow operations; Weather)	3.35, 3.40, 3.46, 7.2a, 7.9-7.13, 7.23e, 7.32	95, 110, 118, 261, 279, 296, 324
Area designator	7.17	285
Arm and hand signals	3.17	74
Arm, aircraft	2.9e, 2.10	34, 35
Armored carrier company	3.1, 7.70-7.72	42, 373
Artificial respiration	7.23	295
Artillery	4.19	155
Assembly, warhead. (<i>See</i> Missile.)		
Association of American Railroads. (<i>See</i> AAR.)		
Astronomical twilight	7.65f	368
Atlantic Coast rivers	5.34b	218
Atmosphere	2.2b, 7.53	4, 350
Atomic attack	7.24	297
Atropine	7.26	306
Attack. (<i>See</i> Air; Atomic; Biological; Chemical; Ground; Nuclear attack.)		
Automobile	3.2, 3.40, 4.4, 4.16, 7.4, 7.9, 7.71	44, 110, 130, 147, 262, 279, 375
Aviation company	2.1	3
B barge	5.13b, 5.14	182, 187
Bacterial toxins	7.25	303
Bad-order car	4.18	150
Baggage	3.49, 4.4, 4.19, 4.20	122, 130, 155, 157
Balance, aircraft	2.2d, 2.3, 2.9	7, 22, 34
Bale cubic capacity	5.52a	233
Ballast:		
Rail	4.6, 4.21	131, 158
Vessel	5.21c	198
Band, high-tension	7.16, 7.36	285, 328
Bandages	7.23	295
BARC (<i>see also</i> Barge; Lighter)	5.1, 5.11, 5.20, 5.36	170, 180, 197, 220
Bareboat charter	5.55a	236
Barehull charter	5.55a	236
Barepole charter	5.55a	236
Barge (<i>see also</i> Floating crane)	5.1, 5.6-5.8, 5.11, 5.13, 5.14, 5.19c, 5.20, 5.26, 5.32c, d, 5.36, 7.4, 7.30	170, 175, 180, 181, 187, 196, 197, 202, 207, 208, 220, 262, 323
Barracks bag	3.49	122

	Paragraph	Page
Barrel, conversion.....	7.53	350
Base line.....	5.53b	234
Battalion.....	2.1, 3.1, 4.1, 4.22, 4.23, 4.28, 4.30, 5.1, 5.2, 5.30c, 5.37, 7.70- 772	3, 42, 124, 162, 164, 167, 168, 170, 173, 206, 221, 373
Battery, storage.....	7.13	284
Battleship.....	5.19a	195
Bayonet (<i>see also</i> Weapons).....	7.7	276
BC barge.....	5.8, 5.20	178, 197
BCI barge.....	5.20	197
BCLI barge.....	5.20	197
BCP barge.....	5.20	197
BCPK barge.....	5.20	197
BCS barge.....	5.20	197
BD crane.....	5.6, 5.20	175, 197
BDL lighter.....	5.9, 5.20	179, 197
Beach:		
Capacity.....	5.35, 7.1	218, 261
Characteristics.....	5.37c	221
Discharge lighter.....	5.9, 5.20	179, 197
Marking.....	5.39	222
Operations.....	5.1, 5.37-5.39, 7.1	170, 221, 261
Profile diagram.....	5.37c	221
Selection.....	5.37c	221
Bearer, human.....	7.3	262
Beaver airplane.....	2.3	22
Beaufort's Scale.....	5.59	241
Bell buoy.....	5.57b	238
Below-deck capacity.....	5.17	188
Bend, rope.....	5.42	225
Berth:		
Ship.....	5.25, 5.29c	200, 205
Terms.....	5.55b	236
Train.....	4.19	155
BG barge.....	5.8, 5.20	178, 197
BGI barge.....	5.20	197
Biological:		
Attack.....	7.25	303
Decontamination.....	7.24d, 7.25c	298, 304
Bird Dog airplane.....	2.3	22
Bite, poisonous, first aid.....	7.23f	296
Bivouac.....	3.8, 3.10c, 7.40	53, 57, 329
BK barge.....	5.8, 5.20	178, 197
BKI barge.....	5.20	197
Blackout.....	3.16e, 3.17b, 4.20	73, 74, 157
Blacksmith repair.....	4.1	124
Blast, nuclear.....	7.24	297
Bleach.....	7.24-7.26	297
Bleeding, first aid.....	7.23a	295
Blisters, first aid.....	7.23j	296
Block and tackle.....	5.49, 7.44	230, 336
Block stowage.....	5.35d	219
Blocking.....	2.14-2.16, 4.8, 4.14, 4.16	36, 132, 141, 147
Blood agent. (<i>See</i> Chemical attack.)		
Board foot.....	7.47c, 7.53	340, 350
Boat.....	5.4, 5.12, 7.4	174, 180, 262
Boat units.....	5.1, 5.2, 7.70-7.72	170, 173, 373
Boeing 707 aircraft.....	2.5	28
Boiler and smith shop company.....	4.1	124
Bolts.....	7.34	328

	Paragraph	Page
Booms.....	7.6g	274
Aircraft.....	2.5, 2.6	28, 31
Rail car.....	4.3	127
Ship.....	5.16, 5.26	187, 202
Box, reusable, metal, shipping.....	3.31, 5.26b, 7.4, 7.14	90, 203, 262, 285
Boxcar (<i>see also</i> Flatcar; Freight car; Open-top car; Gondola).....	4.3, 4.4, 4.17-4.19	127, 130, 149
BPL barge.....	5.8, 5.20	178, 197
BR barge.....	5.20	197
Bracing. (<i>See</i> Blocking.)		
Brakes, rail.....	4.14, 4.19	141, 155
Braking distance, vehicle.....	3.42	113
Breaking strength. (<i>See</i> Tensile strength.)		
Breeze. (<i>See</i> Storm.)		
BRI barge.....	5.20	197
Bridge:		
Highway.....	3.10c, 3.12, 3.13, 3.15b, 3.38	55, 62, 66, 96
Railway.....	4.10, 4.12, 4.13, 4.21, 4.25	133, 138, 158, 165
Waterway.....	5.31b, 5.32c	206, 207
BRO barge.....	5.20	197
Broken stowage.....	5.52b	233
Bucket, grab.....	5.50	231
Building decontamination.....	7.24-7.26	297
Bulldozer.....	7.24	297
Buoy.....	5.57	238
Buoyancy, center of.....	5.53c	234
Burn, first aid.....	7.23b	295
Bus.....	3.2, 3.40	44, 110
Bushel, conversion.....	7.47c, 7.53	340, 350
Burst, nuclear.....	7.24	297
C vessel.....	5.13-5.18	181
C1 vessel.....	5.13b, 5.14, 5.17, 5.18b	182, 187, 188, 193
C2 vessel.....	5.13, 5.17	181, 188
C3 vessel.....	5.13-5.18	181
C4 vessel.....	5.14-5.18	187
C-46F aircraft.....	2.5, 2.6, 2.16	28, 31, 37
C-47D aircraft.....	2.5, 2.6, 2.16	28, 31, 37
C-54G aircraft.....	2.5, 2.6, 2.16, 2.21	28, 31, 37, 38
C-74 aircraft.....	2.5, 2.6, 2.16	28, 31, 37
C-97C aircraft.....	2.5, 2.6, 2.16, 2.21	28, 31, 37, 38
C-118A aircraft.....	2.5, 2.6	28, 31
C-121C aircraft.....	2.5, 2.6, 2.16	28, 31, 37
C-127A aircraft.....	2.5	28
C-123 aircraft.....	2.14	36
C-123B aircraft.....	2.5, 2.6, 2.15, 2.16, 2.21	28, 31, 37, 38
C-124C aircraft.....	2.5, 2.6, 2.16, 2.21, 7.70-7.72	28, 31, 37, 38, 373
C-130 aircraft.....	2.14, 7.70-7.72	36, 373
C-130A aircraft.....	2.5, 2.6, 2.15, 2.16, 2.21	28, 31, 37, 38
C-131A aircraft.....	2.5	28
C-133A aircraft.....	2.5, 2.6, 2.16, 2.21	28, 31, 37
Cable (<i>see also</i> Rope).....	2.16, 5.44, 7.16	37, 227, 285
Cableway.....	7.46	337
Caboose.....	4.4	130
Calendar, 1900-1999.....	7.67	368
Callus, first aid.....	7.23i	296
Camouflage.....	3.8c	54
Camp. (<i>See</i> Bivouac.)		
Can buoy.....	5.57b	238
Can, POL (<i>see also</i> POL).....	7.29, 7.32c	323, 327
Canal.....	5.31, 5.32, 5.34b, 5.54a	206, 207, 210, 235

	Paragraph	Page
Capacity:		
Aircraft.....	2.2-2.6, 2.9g, i, 2.20, 2.23	4, 34, 38
Animal.....	7.2	261
Bale cubic.....	5.52a	233
Barge.....	7.30	323
Beach.....	5.35	218
Boom.....	5.16	187
Commercial vessel.....	5.15	187
Grain cubic.....	5.52c	233
Grab bucket.....	5.50	231
Hook.....	5.47	229
Hoist.....	5.51	233
Inland waterway.....	5.31, 5.32	206, 207
Inland terminal.....	5.33	209
Lighter.....	5.36	220
Load-bearing ice.....	7.10	281
Materiels-handling equipment.....	7.6	273
Motor transport.....	3.2, 3.30, 3.31, 3.33, 3.38, 3.48, 3.49, 7.1, 7.30	44, 89, 90, 92, 96, 120, 122, 261, 323
Parachute.....	2.18	38
Pipeline.....	7.1, 7.27c, d, 7.30	261, 311, 323
POL.....	7.30	323
Rail.....	4.3-4.5, 4.9, 4.13, 4.15-4.19, 4.21, 7.1, 7.30	127, 133, 138, 145, 158, 261, 323
Rope.....	5.40, 5.41	225
Sled.....	7.9b	280
Sled pallet.....	7.16	285
Sling.....	5.47	229
Terminal and water transport.....	5.1, 5.3, 5.4, 5.6- 5.12, 5.15-5.18, 5.22-5.24, 5.28, 5.29, 7.1, 7.30	170, 173, 174, 175, 187, 199, 205, 261, 323
Transporter.....	7.30	323
Tubing.....	7.27d	311
Vehicle.....	3.2, 3.20, 3.33	44, 79, 92
Vessel.....	5.3-5.12, 5.16, 5.17, 7.4, 7.30	173, 187, 188, 262, 323
Wanigan.....	7.9c	280
Wheeled amphibian.....	5.36	220
Wharf.....	5.25c	201
Wire rope.....	5.43	227
Car:		
Automobile.....	3.2, 3.40, 7.71	44, 110, 375
Rail (see also Boxcar).....	4.1, 4.3-4.5, 4.18, 7.4, 7.71	124, 127, 150, 262, 375
Company.....	3.1, 5.2, 7.70-7.72	42, 173, 373
Repair company.....	4.1	124
Carbine. (See Weapons.)		
Carbon-monoxide poisoning.....	7.23i	296
Cargo:		
Capacity. (See Capacity.)		
Carrier.....	3.1, 3.2, 7.70-7.72	42, 44, 373
Deadweight tonnage.....	5.54b	235
Hold.....	5.16-5.18	187
Hook.....	5.47	229
Loading:		
Aircraft.....	2.5b, 2.13-2.15, 2.21a	29, 35, 38
Rail car.....	4.9, 4.14-4.16	133, 141
Vehicle.....	3.29	88
Vessel.....	5.26, 5.35d	202, 219

	Paragraph	Page
Cargo (Cont)		
Marking.....	2.7b, 2.11, 7.17, 7.18	33, 35, 285, 289
Net.....	2.16, 3.31, 5.26b	37, 90, 203
Priority.....	2.11, 2.12, 7.17	35, 285
Transporter.....	3.31, 7.4, 7.14	90, 262, 285
Vessel.....	5.3, 5.4, 5.7-5.20	173, 174, 176
Cargomaster aircraft.....	2.5, 2.6	28, 31
Caribou airplane.....	2.2b, 2.3	4, 22
Carrier:		
Aircraft.....	5.14, 5.19a	187, 195
Cargo.....	3.1, 3.2, 7.71	42, 44, 375
Personnel.....	3.1, 3.2, 7.71	42, 44, 375
Carrier company.....	3.1, 7.70-7.72	42, 373
Cartridge. (See Ammunition.)		
Casualty (see also Medical treatment).....	7.2b, 7.23	261, 295
Catenary system.....	4.1	124
CBR attack, decontamination, and defense.....	7.24-7.26	297
Center of buoyancy, vessel.....	5.53c	234
Center of gravity:		
Aircraft.....	2.2d, 2.9b, 2.10	7, 34, 35
Vessel.....	5.53c	234
Chain.....	2.16, 5.45, 5.46d, 5.51, 7.47a	37, 227, 228, 233, 339
CH-21C helicopter.....	2.3	22
CH-34C helicopter.....	2.3	22
CH-37B helicopter.....	2.3	22
CH-47A helicopter.....	2.3	22
Channel.....	5.31a, j, 5.38c, 557	206, 222, 238
Chart:		
Harbor.....	5.29	205
Time-zone.....	7.64b	363
Charter, terms.....	5.55	236
Checklist:		
Convoy.....	3.24	84
Highway capacity.....	3.38d	98
Maintenance shop.....	3.41b	111
Motor park.....	3.41	111
Terminal capacity.....	5.23, 5.33	199, 209
Vehicle.....	3.41c	113
Chemical attack.....	7.26	306
Chemical, biological, radiological attack, decontamination, and defense.....	7.24-7.26	297
Chemical decontamination.....	7.24d, 7.26b	298, 307
Chemical equipment and supply.....	7.4, 7.54, 7.55	262, 351
Chespalang mat.....	3.46	118
Chickasaw helicopter.....	2.3	22
Chill factor.....	7.12	281
Chinook helicopter.....	2.3	22
Chlorination, water.....	7.42b	334
Choctaw helicopter.....	2.3	22
Choking agent. (See Chemical Attack.)		
Chord, measurement.....	4.27	167
Circle.....	7.47d, 7.58	340, 357
Civil twilight.....	7.64a, 7.65f	363, 368
Clamshell.....	5.50	231
Clearance:		
Aircraft door.....	2.5, 2.6	28, 31
Brake wheel.....	4.14	141
Capacity, terminal.....	5.23-5.25, 5.33	199, 209
Convoy.....	3.26	86
Hatch.....	5.17	188
Rail.....	4.3, 4.10, 4.12, 4.25	127, 133, 138, 165
Classes of supply.....	3.36, 7.31, 7.38, 7.54, 7.55, 7.70	95, 324, 329, 351, 373

Classification (<i>see also</i> Designator):	Paragraph	Page
Berth.....	5.25b	200
Bridge:		
Highway.....	3.12, 3.13, 3.15b	62, 66
Rail.....	4.13	138
Locomotive.....	4.2, 4.13	126, 138
Road.....	3.11b	60
Route.....	3.11a	59
Sign, road.....	3.14	62
Signal equipment.....	7.19a	290
Vehicle.....	3.13	62
Vessel.....	5.13, 5.19, 5.20, 5.25b	181, 195, 197, 200
Yard.....	4.21c	161
Clothing.....	4.9, 7.24-7.26, 7.56	133, 297, 351
Cloverleaf packing.....	4.16	147
Coach, day.....	4.5, 4.19a, c	131, 155, 157
Coal.....	5.13, 5.14, 7.31	181, 187, 324
Coast Guard, U. S., shipment marking.....	7.18e	290
Code (<i>see also</i> Abbreviations; Designations; Signals):		
Air movement.....	2.11	35
Ground-air.....	7.21	291
International.....	7.20	291
Morse.....	7.20a	291
Project.....	7.17a	285
Shipping address.....	7.17a	285
Cold-weather data. (<i>See</i> Arctic data; Snow operations; Weather.)		
Color, buoy.....	5.57c	239
Color marking.....	7.18	289
Column length.....	3.19	79
Combat.....	2.1, 3.36, 4.22, 5.1, 5.36	3, 95, 162, 170, 220
Combat loading, vessel.....	5.26b, 5.35d	203, 219
Combatant vessel.....	5.19a	195
Combat order, log, and strip map.....	3.22	82
Command:		
Airplane.....	2.20	38
Wanigan.....	7.9c	280
Commando aircraft.....	2.5, 2.6	28, 31
Commitment, vehicle.....	3.6	52
Commercial vessels.....	5.14, 5.15, 5.26a	187, 202
Commodity loading, vessel.....	5.26b, 5.35d	203, 219
Communications (<i>see also</i> Signal).....	4.8, 4.21, 4.23, 5.58, 7.4, 7.19-7.22	132, 158, 164, 239, 262, 290
Company, movement.....	3.34, 4.19b, 5.35d, 7.57, 7.70-7.72	95, 157, 219, 373
Company:		
Aircraft direct support.....	2.1, 7.70-7.72	3, 373
Aircraft heavy maintenance and supply.....	2.1, 7.70-7.72	3, 373
Aircraft maintenance.....	2.1	3
Amphibian general support.....	5.1, 5.2	170, 173
Amphibious truck.....	5.1, 5.2, 7.70-7.72	170, 173, 373
Armored carrier.....	3.1, 7.70-7.72	42, 373
Army aircraft heavy maintenance and supply.....	2.1	3
Aviation.....	2.1	3
Boiler and smith shop.....	4.1	124
Car.....	3.1, 5.2, 7.70-7.72	42, 173, 373
Car repair.....	4.1	124
Cargo carrier (tracked).....	3.1, 7.70-7.72	42, 373
Depot.....	4.1, 4.34, 7.70-7.72	124, 169, 373
Diesel-electric locomotive repair.....	4.1	124
Electric power transmission.....	4.1	124
Engineer port construction.....	5.2	173

	Paragraph	Page
Company (Cont)		
Erecting and machine shop.....	4.1	124
Floating craft depot maintenance.....	5.1, 5.2	170, 173
Heavy amphibian.....	5.1, 5.2	170, 173
Heavy boat.....	5.1, 5.2	170, 173
Heavy truck.....	3.1, 3.30, 3.34	42, 89, 95
Light amphibian.....	5.1, 5.2	170, 173
Light boat.....	5.1, 5.2	170, 173
Light helicopter.....	2.1, 7.70-7.72	3, 373
Light helicopter direct support maintenance and supply company....	2.1	3
Light transport helicopter direct support maintenance and supply company.....	2.1	3
Light truck.....	3.1, 3.30, 3.33a, 3.34, 7.70-7.72	42, 89, 93, 95, 373
Medium airplane.....	2.1	3
Medium amphibian.....	5.1, 5.2	170, 173
Medium boat.....	5.1, 5.2	170, 173
Medium helicopter.....	2.1	3
Medium truck.....	3.1, 3.30, 3.33b, 3.34, 7.70-7.72	42, 89, 93, 95, 373
Military police.....	5.2	173
Motor transport.....	3.1	42
Ordnance motor vehicle assembly.....	5.2	173
Quartermaster service.....	5.2	173
Railway engineering.....	4.1, 7.70-7.72	124, 373
Railway equipment.....	4.1, 7.70-7.72	124, 373
Staging area.....	5.1, 5.2, 7.70-7.72	170, 173, 373
Tactical carrier.....	3.1, 7.70-7.72	42, 373
Terminal service.....	5.1, 5.2, 5.22a, 5.29f, 7.70-7.72	170, 173, 199, 206, 373
Train operating.....	4.1, 7.70-7.72	124, 373
Transport aircraft direct support.....	2.1, 7.70-7.72	3, 373
Compound tackle.....	5.49	230
Compressor.....	7.6	273
Cone, measurement.....	7.58	357
CONEX.....	3.31, 5.26b, 7.4, 7.14, 7.18	90, 203, 262, 285, 289
Consignee.....	4.15d, 4.18c, 7.17	146, 155, 285
Constant-speed propeller.....	2.2c	5
Construction:		
Railway.....	4.21, 4.23, 4.24	158, 164, 165
Terminal.....	5.22	199
Consumption rate.....	7.37a	329
Container.....	2.19, 3.31, 4.17, 5.26b, 7.4, 7.5, 7.14, 7.17, 7.18, 7.29, 7.32c	38, 90, 149, 203, 262, 270, 285, 289, 323, 327
Contamination, CBR.....	7.24-7.26	297
Contour, map.....	7.69d	371
Control device, train (see also Communications; Signal).....	4.21, 4.23, 4.24	158, 164, 165
CONUS address marking.....	7.17c	289
CONVAIR 880 aircraft.....	2.5	28
Conversion:		
Angular.....	7.47d	340
Cubic.....	7.47c	340
Decimals.....	7.60	359
Density.....	7.47i	342
Foreign measure.....	7.52	348
Linear measure.....	7.47a	339
Map-distance.....	7.50	347
Petroleum.....	7.48, 7.49	346, 347
Power.....	7.47c	340
Pressure.....	7.47i	342

	Paragraph	Page
Conversion (Cont)		
Speed.....	7.47g, 7.51	342, 348
Surface.....	7.47b	339
Temperature.....	7.47h	342
Time.....	7.64b	363
Weight.....	7.47f	341
Conveyor.....	2.5, 2.6, 5.26b	28, 31, 203
Convoy.....	3.4, 3.24-3.26	51, 84
Coolant, vehicle.....	3.2, 7.11	44, 281
Cooper's E rating.....	4.13	138
Coordinates.....	7.69	370
Corporal missile.....	3.33, 7.5	92, 270
Corps of Engineers. (See Engineers.)		
Covered shop floorspace.....	7.39	329
Covered storage.....	5.27b, 7.38	205, 329
Covered terminal.....	5.25c	201
Corvette vessel.....	5.19a	195
Crane.....	3.31, 4.3, 5.6, 5.20, 7.4, 7.6, 7.71	90, 127, 175, 197, 262, 273, 375
Crawler crane.....	7.6g	274
Crew:		
Aircraft.....	2.2, 2.5a, 2.9	4, 28, 34
Rail maintenance.....	4.1, 4.24-4.26	124, 165
Train.....	4.1, 4.18b, 4.20b	124, 153, 157
Vessel.....	5.3-5.8, 5.10, 5.11	173, 179, 180
Cruiser.....	5.19a	195
Cruising range. (See Range.)		
Cubic measure.....	7.47e, 7.53, 7.58	340, 350, 357
Culvert:		
Highway.....	3.10c	57
Rail.....	4.21, 4.23, 4.27	158, 164, 167
Curve, road.....	3.38c	97
Curvature, track.....	4.3, 4.6, 4.28-4.30	127, 131, 167
Cutter, wire.....	4.18c	155
CV-2 aircraft.....	2.2b, 2.3	4, 22
Cylinder, measurement.....	7.28b, 7.58	314, 357
D7 LPG tractor.....	7.9a	279
D8 LPG tractor.....	7.9a	279
DANC solution.....	7.24-7.26	297
Date designator.....	7.17, 7.64a	285, 363
Davy Crockett missile.....	7.5	270
Day coach.....	4.5, 5.19a, c	131, 195, 196
Day of supply.....	7.37b	329
Daylight, hours of.....	7.66	368
Day's dispatch, rail.....	4.22d	162
DC-8 aircraft.....	2.5	28
Deadman, field expedient.....	3.43, 3.45	115, 116
Deadweight:		
Scale.....	5.21	197
Tonnage.....	5.54c	235
Debarkation point markings.....	5.39	222
Decimal equivalents.....	7.60	359
Decontamination, CBR.....	7.24-7.26	297
Defense against attack.....	3.8, 4.20, 7.24	53, 157, 297
Degree, conversion of.....	7.47d	340
Degree of curvature.....	4.28	167
Delivery date.....	7.17a	285
Demise charter.....	5.55a	236
Demolition, rail.....	4.21b	158
Denatured alcohol.....	7.11	281
Density:		
Air.....	2.2b	4
Conversion.....	7.47j	342

	Paragraph	Page
Density (Cont)		
Traffic.....	3.21	81
Train.....	4.21b	158
Depot:		
Company.....	4.1, 4.34, 7.70-7.72	124, 169, 373
Maintenance:		
Air.....	2.1	3
Motor.....	3.1, 3.39	42, 109
Rail.....	4.1, 4.8g, 4.24-4.26	124, 132, 165
Terminal.....	5.1, 5.2	170, 173
Train.....	4.1, 4.18c, 4.34	124, 155, 169
Truck.....	3.7	52
Derrick (<i>see also</i> Crane).....	5.44	227
Desert operations.....	7.23d	295
Designator (<i>see also</i> Abbreviation; Marking):		
Air movement.....	2.11, 7.17a	35, 285
Area.....	7.17	285
Date.....	7.17, 7.64a	285, 363
Floating craft.....	5.3-5.8, 5.13, 5.14, 5.19, 5.20	173, 181, 187, 195, 197
Port.....	7.17a	285
Service.....	7.17	285
Shipping.....	7.17	285
Time.....	7.64	363
Destroyer.....	5.19a	195
Detection devices, CBR.....	7.24d	298
Detergent.....	7.24-7.26	297
Diagram:		
Beach profile.....	5.37c	221
Profile loading.....	5.26b	203
Rail.....	4.12	138
Diesel-electric locomotive.....	4.1-4.3, 4.24-4.26	124, 165
Diesel fuel (<i>see also</i> POL).....	3.48, 7.9d	120, 280
Diesel-mechanical locomotive.....	4.3	127
Differential hoist.....	5.51	233
Dining car.....	4.3, 4.4	127, 130
Direction, horizontal.....	7.69c	370
Discharge rate, terminal.....	5.23, 5.25, 5.26, 5.29c, 5.33, 7.1	199, 200, 202, 205, 209, 261
Dispersion.....	3.8, 7.40	53, 329
Dispatching, train (<i>see also</i> Scheduling).....	4.1, 4.6w, 4.18b	124, 131, 153
Displacement:		
Ton.....	5.54d	236
Tonnage.....	5.54d, f	236
Vessel.....	5.3-5.11, 5.21	173, 197
Distance:		
Conversion.....	7.50	347
Factors, march.....	3.18d	75
Horizontal.....	7.69d	371
Sailing.....	5.56	237
Stopping, vehicle.....	3.42	113
Distillation, water.....	7.42a	334
Diversion and reconsignment.....	3.4b	51
Division:		
Army.....	2.1, 3.1, 4.1, 4.19a, 5.1, 6.6, 6.7, 7.1	3, 42, 124, 155, 170, 250, 253, 261
Railway.....	4.21, 4.23, 4.24, 4.33	158, 164, 165, 168
Documentation (<i>see also</i> Records and reports).....	2.2, 2.8, 3.25, 3.26, 4.8f, 4.18a, b, 7.17	4, 34, 86, 132, 150, 153, 285
Dog. (<i>See</i> Animal.)		
Dolly.....	3.2, 7.4, 7.71	44, 262, 375
Domestic address.....	7.17d	289
Dosage, radiation.....	7.24f	303

	Paragraph	Page
Down by the head	5.53d	234
Down by the stern	5.53d	234
Draft, vessel	5.3-5.12, 5.15, 5.21, 5.53e	173, 187, 197, 234
Drag, floating craft	5.53f	234
Drill equipment	7.6	273
Drowning, first aid	7.23g	296
Drum:		
POL	7.29, 7.32c	323, 327
Winch	5.48	229
Drydock	5.19c, 5.20	196, 197
DUKW. (See Landing vehicle, wheeled.)		
Dump	3.7, 3.10	52, 55
EC-2 vessel. (See Liberty ship.)		
Echelons of maintenance	2.1, 2.24, 3.1, 3.39, 4.1, 4.24-4.26, 5.1	3, 40, 42, 109, 124, 165, 170
Electria 188 airplane	2.5	28
Electric:		
Locomotive	4.2	126
Power transmission	4.1, 4.21	124, 158
Shock, first aid	7.23h	296
Electricity	7.47	339
Electrolyte	7.13	284
Electronic equipment	7.19	290
Elevator:		
Aircraft	2.6	31
Vessel	5.26b	203
Elevation	7.69d	371
Ellipse, measurement	7.28d, 7.58	322, 357
Embarkation order	6.7	253
Emergency:		
Medical treatment	7.23	295
Message, ground-air	7.21	291
Enemy:		
Forces	3.8, 4.20, 4.23, 4.27, 7.24	53, 157, 164, 167, 297
Material	4.30	168
Engine:		
Aircraft	2.2c	5
Railway. (See Locomotive.)		
Vessel	5.13, 5.14	181, 187
Engineer, railway	4.24a, 4.26	165, 166
Engineers	4.13b, 4.19, 4.21, 5.2, 7.6, 7.54, 7.55	138, 155, 158, 173, 273, 351
Enginehouse	4.6g, 4.10c, 4.24-4.26	131, 133, 165
Equivalents	7.47-7.57, 7.60	339, 359
Equipment (see also particular item):		
Air transportability	7.71	375
Chemical	7.4, 7.24-7.26	262, 297
Decontamination of	7.24-7.26	297
Engineer	7.6, 7.24-7.26	273, 297
Individual	7.56c	356
Medical	7.4, 7.23	262, 295
Motor (see also Vehicle)	3.2, 3.3, 3.33	44, 51, 92
Ordnance (see also Ammunition; Missile; Weapons)	7.4	262
Organizational	4.19b, 7.56d	157, 357
Quartermaster (see also Supply)	7.4	262
Rail	4.2, 4.3, 7.4	126, 127, 262
Signal	7.4, 7.19, 7.22	262, 290, 294
Terminal and water transport	5.3-5.11, 5.22, 5.28, 5.29f, 7.4	173, 199, 205, 206, 262

	Paragraph	Page
Equipment (<i>see also</i> particular item) (Cont)		
Tonnage.....	5.54g	236
Erecting and machine shop company.....	4.1	124
Escort vessel.....	5.19a	195
Estimates (<i>see also</i> Planning).....	7.1	261
Amphibious operation.....	5.35-5.37	218
Aircraft capability.....	2.23	38
Discharge rate.....	5.26	202
Highway capability.....	3.38	96
Inland waterway.....	5.31, 5.32	206, 207
Intelligence.....	6.9	254
LOTS operations.....	5.35-5.37	218
Pipeline.....	7.27	311
Rail.....	4.6, 4.19, 4.21, 4.23	131, 155, 158, 164
Transportation.....	6.10	255
Vessel capacity.....	5.21b	197
Water terminal.....	5.22-5.24, 5.26, 5.28, 5.29	199, 202, 205
ET vessel (<i>see also</i> Tanker).....	5.13b	182
Expedients:		
Field.....	3.43-3.47, 7.42-7.46	115, 334
First aid.....	7.23	295
Explosives (<i>see also</i> Ammunition).....	3.32, 4.16, 4.17	91, 147, 149
Explosions, nuclear.....	7.24	297
F vessel.....	5.20	197
FB vessel.....	5.20	197
Factors:		
Aircraft weight and balance.....	2.5c	30
Conversion.....	7.47-7.57	339
Rail.....	4.6	131
Replacement.....	7.37c	329
Safety.....	2.15a, 5.40, 5.44, 5.49, 7.12	37, 225, 227, 230, 281
Stowage.....	5.52d, 5.53r, 7.54, 7.55	233, 234, 351
Vessel.....	5.53r	234
Windmill.....	7.12	281
Fairway marking.....	5.38c	222
Fallout.....	7.24b	297
Farm sled.....	7.9b	280
Fathom, conversion.....	7.47a	339
FD drydock.....	5.20	197
Feet, conversion.....	7.47, 7.53	339, 350
Ferryboat.....	3.10c, 5.20	57, 197
Field:		
Army.....	2.1, 3.1, 3.26, 7.1	3, 42, 86, 261
Equipment.....	7.56d	357
Expedients.....	3.43-3.47, 7.23-7.26, 7.43-7.46	115, 295, 336
Maintenance.....	2.1, 2.23, 2.24, 3.39, 4.1, 4.8g, 4.24, 4.25	3, 38, 40, 109, 124, 132, 165
Filter:		
Respirator.....	7.24-7.26	293
Water.....	7.42c	334
Fin, rocket.....	7.5	270
Finance service organization.....	5.2	173
Fire prevention.....	3.32	91
Fireboat.....	5.20	197
Firearm.....	4.26	166
First aid.....	7.23	295
Fitting-out wharf.....	5.25c	201
Fixed-pitch propeller.....	2.2c	5

	Paragraph	Page
Fixed-wing aircraft. (<i>See</i> Airplane.)		
Flag, signal.....	7.20a	291
Flagship.....	5.12	180
Flares (<i>see also</i> Signal).....	3.8d	54
Flatcar (<i>see also</i> Boxcar).....	4.3, 4.4, 4.14, 4.19	127, 130, 141, 155
Flight rules.....	2.2b	4
Floating:		
Craft.....	5.3, 5.11	173, 180
Depot maintenance company.....	5.1, 5.2	170, 173
Crane.....	5.6, 5.20	175, 197
Drydock.....	5.19c, 5.20	196, 197
Repair shop.....	5.8, 5.20	178, 197
Floorspace, shop.....	7.39	329
Fluids, formula.....	7.27	311
FMS vessel.....	5.8, 5.20	178, 197
Food decontamination (<i>see also</i> Rations).....	7.24f	303
Foot ailments.....	7.23j	296
Foot-pounds, conversion.....	7.47e	340
Fordability, vehicle.....	3.2	44
Foreign:		
Measures.....	7.52	348
Railroads.....	4.3, 4.6, 4.11, 4.12, 4.17, 4.18, 4.19c, 4.28	127, 131, 133, 138, 149, 150, 157, 167
Troops.....	4.20a	157
Forklift.....	3.31, 3.47, 4.16a, 5.32c, 7.6, 7.15	90, 118, 147, 207, 273, 285
Forms:		
Department of the Army.....	3.10c, 4.24-4.26, 5.37, App. I	57, 165, 221, 385
Department of Defense.....	3.26, 4.25b, App. I	86, 165, 385
Formula:		
Aircraft.....	2.15, 2.23, 2.25, 2.26	37, 38, 40
Gradient.....	7.68	370
Lashing.....	2.15	37
Liquid.....	7.28	313
Logarithm.....	7.59	358
Motor transport.....	3.18, 3.21, 3.34	74, 81, 95
Pipeline.....	7.27a	311
Rail.....	4.21, 4.22	158, 162
Sling tension.....	5.46	227
Solid.....	7.58	357
Stowage.....	7.54	351
Surface.....	7.58	357
Terminal.....	5.32, 5.36	207, 220
Forward perpendicular.....	5.53g	234
Four-boom rigs.....	5.26b	203
Foxhole.....	3.8, 7.24c	53, 298
Fracture, first aid.....	7.23c	295
Free alongside ship.....	5.55d	236
Freeboard.....	5.53h	234
Free in and out.....	5.55e	236
Free of address.....	5.55f	236
Free of turn.....	5.55g	236
Free on board.....	5.55h	236
Free time.....	5.55i	236
Freight:		
Car (<i>see also</i> Boxcar).....	4.3, 4.4, 4.9, 4.16, 4.19c	127, 130, 133, 147, 157
Forward.....	5.55j	236
Prepaid.....	5.55j	236
Ton.....	5.54l	236
Train.....	4.8d, 4.19a	132, 155

	Paragraph	Page
Freighter.....	5.16, 5.17, 5.20	187, 188, 197
Frigate.....	5.19a	195
Frostbite, first aid.....	7.23e	296
FS vessel.....	5.3, 5.16, 5.17, 5.20	173, 187, 188, 197
FSM vessel.....	5.20	197
FSR vessel.....	5.3, 5.20	173, 197
Fuel. (See POL.)		
Full and down.....	5.53i	234
Full-feathering propeller.....	2.2c	5
Functions, mathematical.....	7.59, 7.62	358, 361
Fuse.....	3.32, 7.32b	91, 325
Gage, track.....	4.3, 4.6, 4.11, 4.12, 4.21a, 4.25b	127, 131, 133, 138, 158, 165
Gale. (See Storm.)		
Gallon:		
Conversion.....	7.27a, 7.47c, 7.53	311, 340, 350
POL.....	7.48	346
Gas attack. (See Chemical attack.)		
Gasoline (see also POL).....	7.27-7.30, 7.32c, 7.49	311, 327, 347
Gasoline-mechanical locomotive.....	4.3	127
Generator.....	7.6, 7.9d	273, 280
Geneva Convention.....	3.14-3.16	62
Gin pole.....	7.45	336
Globemaster aircraft.....	2.5, 2.6	28, 31
Goggles.....	7.24-7.26	297
Gondola (see also Boxcar).....	4.3, 4.4, 4.14	127, 130, 141
Gong buoy.....	5.57b	238
Grab bucket.....	5.50	231
Gradient.....	3.38c, 4.6j, 4.21, 4.22, 4.31, 7.68	97, 131, 158, 162, 168, 370
Grain cubic capacity.....	5.52c	233
Grain, conversion.....	7.53	350
Graph, road-movement.....	3.20	79
Gravity, center of:		
Aircraft.....	2.2d, 2.9b, 2.10	7, 34, 35
Vessel.....	5.53c	234
Grease (see also Lubricant).....	3.48, 7.9d, 7.27- 7.30, 7.32c, 7.49	120, 280, 311, 327, 347
Greenwich mean time.....	7.64a	363
Grenade.....	7.32b	325
Grenade launcher.....	3.8e, 7.7	54, 276
Grid:		
Coordinator.....	7.69e	372
North.....	7.69c	370
Groove diameter.....	5.48	229
Gross ton.....	5.54h	236
Gross tonnage.....	5.54i	236
Gross trailing load.....	4.21b	158
Ground:		
Attack.....	3.8, 4.20	53, 157
Pressure psi.....	3.2	44
Time, aircraft.....	2.21	38
Ground-air emergency messages.....	7.21	291
Group:		
Motor transport.....	3.1, 7.70-7.72	42, 373
Railway.....	4.1, 4.24, 4.33	124, 165, 168
Guards, rail.....	4.18b, 4.19a	153, 155
Guerrillas.....	3.8	53
Guided missile. (See Missile.)		
Gulf Coast rivers.....	5.34b	210
Guns. (See Weapons.)		
Gunboat.....	5.16	187

	Paragraph	Page
Guys.....	5.43, 5.44, 7.45, 7.63	227, 336, 361
Halt, motor transport.....	3.4a, 3.10c, 3.22b	51, 57, 84
Hand signals.....	3.17	74
Handbrake, rail.....	4.14a	141
Harbor:		
Chart.....	5.2	173
Craft.....	5.1, 5.3-5.8, 7.4	170, 173, 262
Tug.....	5.5	175
Hatch:		
Data.....	5.16-5.18	187
Loading.....	5.26b	203
Haul, motor transport.....	3.30, 3.34	89, 95
Haulage rope.....	5.44	227
Hawk missile.....	7.5	270
Hazardous cargo.....	3.31, 3.32, 4.15-4.17	90, 92, 145
Heat, first aid.....	7.23d	295
Heavy-lift:		
Capacity, vessel.....	5.16	187
Equipment (<i>see also</i> Crane; Derrick; Forklift).....	7.6	273
Helicopter (<i>see also</i> Aircraft; Airplane).....	2.1-2.5, 2.20a, 2.23, 2.24, 2.27, 7.10	3, 38, 40, 41, 281
Company.....	2.1, 7.70-7.72	3, 373
Team.....	2.1	3
Hercules aircraft.....	2.5, 2.6	28, 31
High-tension bands.....	7.36	328
High-speed transport.....	5.12	180
Highway (<i>see also</i> Motor transport; Road; Route):		
Capacity.....	3.38, 7.1	96, 261
Curve.....	3.38c	97
Gradient.....	3.38c	97
Limitations.....	3.50	122
Scheduling request.....	3.28	87
Surface.....	3.38c	97
Units.....	3.1, 5.2, 7.70-7.72	42, 173, 373
Width.....	3.38c	97
Hitch, rope.....	5.42	225
Hogging, vessel.....	5.53	234
Hoist.....	2.6, 5.6, 5.43, 5.44, 5.51, 7.43	31, 175, 227, 233, 336
Hold data.....	5.16-5.18	187
Holdfast.....	3.43a	115
Honest John missile.....	3.33, 7.5	92, 270
Hook.....	5.47	229
Hopper car (<i>see also</i> Boxcar).....	4.3	127
Horizontal:		
Direction.....	7.69c	370
Distance.....	7.69c	370
Tank.....	7.28c	318
Horse. (<i>See</i> Animal.)		
Horsepower:		
Aircraft engine.....	2.2c	5
Conversion.....	7.47e, 7.53	340, 350
Locomotive.....	4.3a	127
Hour, conversion.....	7.53	350
Hours of daylight.....	7.66	368
Human bearers.....	7.3	262
Humidity.....	2.2b	4
Hurricane. (<i>See</i> Storm.)		
Husky M116.....	7.9a	279
Hydrographic marking.....	5.38	222
I-beam bridge.....	4.13b	131
Ice (<i>see also</i> Arctic data).....	7.10	288

	Paragraph	Page
Ice capacity, rail car.....	4.3c, 4.4	128, 130
Icebreaker, vessel.....	5.19b	196
Inch, conversion.....	7.47a, l, 7.53, 7.60	339, 343, 350, 359
Initial tonnage.....	5.24	200
Inland waterway.....	5.7, 5.20, 5.30-5.34, 5.57	176, 197, 206, 238
Insert, container.....	7.14	285
Inspection.....	2.7, 3.41c, 4.1, 4.8f, g, 4.23-4.26	33, 113, 124, 132, 164
Instrument flight rules.....	2.2b	4
Intelligence.....	2.2b, 2.8b, 3.5b, 4.8i, 5.37c, 6.8-6.10	4, 34, 51, 132, 221, 254
International road signs.....	3.14, 3.15	62, 66
Interstate Commerce Commission.....	4.16	147
In-the-clear address.....	7.17a	285
Iroquois helicopter.....	2.3	22
Iron chain.....	5.45	227
J boat.....	5.4, 5.20	174, 197
Jet fuel (<i>see also</i> POL).....	7.27-7.30	311
Jumbo boom.....	5.26b	203
Keel line.....	5.53	234
Kerosene (<i>see also</i> POL).....	3.48, 7.9, 7.27-7.30, 7.32c	120, 279, 311, 327
Kilogram, conversion.....	7.47f	341
Kilometer, conversion.....	7.47a	339
Kilowatt, conversion.....	7.47e	340
Kitchen.....	4.3f, 4.19, 7.40f	130, 155, 330
Knot, rope.....	5.42	225
L tanker.....	5.13b, 5.14	182, 187
Label, shipment (<i>see also</i> Marking).....	4.17, 7.17	149, 285
Lacrosse missile.....	3.33, 7.5	92, 270
Lakes.....	5.31, 5.32	206, 207
Landing:		
Aircraft.....	2.2b, 2.22, 2.27	4, 38, 41
Craft.....	5.1, 5.10, 5.12, 5.20, 5.36, 7.4, 7.16	170, 179, 180, 197, 220, 262, 285
Operation.....	5.37-5.39	221
Ship.....	5.9, 5.19a	179, 191
Vehicle:		
Tracked.....	3.2, 4.14, 5.11	44, 141, 180
Wheeled.....	4.14b, 5.1, 5.11, 5.20, 5.35, 5.36, 5.39	143, 170, 180, 197, 218, 220, 222
Lane, traffic.....	3.38c	97
LARC (<i>see also</i> Lighter).....	5.1, 5.11, 5.20, 5.36, 7.4	170, 180, 197, 220, 262
Lashing:		
Air cargo.....	2.3, 2.5b, 2.13-2.16	22, 29, 62
Rail cargo.....	4.14-4.16	141
Latrine.....	7.40d	330
Launcher:		
Grenade.....	3.8e, 7.7	54, 276
Rocket.....	3.8e, 7.4, 7.7	262, 276
Lay days.....	5.55k	236
LCM vessel.....	5.10, 5.12, 5.20	179, 180, 197
LCR vessel.....	5.20	197
LCU vessel.....	5.10	179
LCVP vessel.....	5.10, 5.12, 5.20	179, 180, 197
Length, column.....	3.19	79
L-head pier.....	5.25c	201
Liberty ship.....	5.13-5.18	181
Life saving.....	7.23	295

	Paragraph	Page
Liferaft.....	2.6	31
Liftmaster aircraft.....	2.5, 2.6	28, 31
Light, buoy.....	5.57, 5.58	238, 239
Lighter (<i>see also</i> BARC; Landing craft; Landing vehicles; LARC).....	5.1, 5.9, 5.11, 5.19c, 5.20, 5.25, 5.29, 5.36, 7.4	170, 179, 180, 194, 197, 200, 205, 220, 262
Line:		
Base.....	5.53b	234
Keel.....	5.53k	234
Rope.....	5.40-5.44	225
Line haul.....	3.30	89
Linear measure, conversion.....	7.47a	339
Liquid-cargo vessel (<i>see also</i> POL).....	5.3, 5.7, 5.8, 5.15, 5.20	173, 176, 178, 187, 197
Liquid oxygen.....	7.5	270
Liquids, data.....	7.27, 7.28	311, 313
Litter, casualty.....	2.5, 7.2, 7.23	28, 261, 295
Little John missile.....	3.33, 7.5	92, 270
Load waterline.....	5.13, 5.53l	181, 235
Loading:		
Aircraft.....	2.2d, 2.3, 2.5b, 2.7, 2.9, 2.10, 2.13, 2.14, 2.17, 2.20, 2.23, 7.70-7.72	7, 22, 29, 33, 34, 35, 36, 38, 373
Railcars.....	4.6i, 4.8e, 4.9, 4.14-4.18	131, 132, 133, 150
Vehicles.....	3.29, 3.36, 3.40	88, 95, 110
Vessels.....	5.18, 5.26, 5.35d	190, 202, 218
Loadline.....	5.53m	234
Local:		
Haul.....	3.30	89
Purchase.....	4.28	167
Lock, canal.....	5.31d, 5.32c	206, 207
Locomotive.....	4.1-4.3, 4.8, 4.13a, 4.21, 4.22, 4.24-4.26, 7.4	124, 132, 138, 158, 162, 165, 262
Log:		
Presto.....	7.9d	280
Road-movement.....	3.23	84
Logarithms.....	7.59	358
Logistical:		
Command.....	2.1, 3.1, 5.1, 7.1	3, 42, 170, 261
Operations.....	2.1, 3.1, 4.1, 5.1, 5.37, 6.2, 7.1, 7.37	3, 42, 124, 170, 221, 242, 261, 329
Long ton.....	5.54j	236
LOTS operation.....	5.37	221
LPD vessel.....	5.26b	203
LPH vessel.....	5.26b	203
LSD vessel.....	5.9	179
LST vessel.....	5.9	179
LT tug.....	5.5, 5.20	175, 197
LTI vessel.....	5.20	197
Lubricants (<i>see also</i> POL).....	3.2, 3.48, 4.24-4.26, 4.28, 7.9a, 7.27- 7.31, 7.32c, 7.48	44, 120, 165, 167, 279, 311, 327, 346
LVTP.....	5.11	180
Machinegun. (<i>See</i> Weapons.)		
Magnetic north.....	7.69c	370
Mail.....	4.18b, 5.2, 7.2	153, 173, 261
Maintenance:		
Air.....	2.1, 2.8f; 2.23-2.26	3, 34, 38
Motor.....	3.1, 3.5f, 3.39, 3.41, 7.11, 7.39	42, 52, 109, 111, 281, 329

	Paragraph	Page
Maintenance (Cont)		
Rail (<i>see also</i> Maintenance-of-way).....	4.1, 4.8 <i>g</i> , 4.21, 4.26- 4.27, 7.39	124, 132, 158, 166, 329
Terminal.....	5.1, 5.2, 5.31 <i>i</i> , 5.36 <i>d</i>	170, 173, 206, 221
Maintenance-of-way.....	4.23, 4.24, 4.27	164, 165, 167
Major command SOP.....	6.5	248
Man-hour requirements for		
Aircraft maintenance.....	2.24, 2.25	40
Railway construction.....	4.21	158
Railway maintenance.....	4.24-4.26	165
Manifest ton.....	5.54 <i>k</i>	236
Manila rope.....	5.40, 5.41, 5.46 <i>c</i> , 5.49	225, 228, 230
Map.....	3.7, 3.22, 3.23, 7.50, 7.69, App III	52, 82, 84, 347, 370, 397
March.....	3.17, 3.18, 3.20	74, 79
Marginal pier.....	5.25 <i>c</i>	201
Marine Corps, shipment marking.....	7.18 <i>c</i>	290
Marine fleet classification.....	5.20	197
Mariner-class vessel.....	5.14-5.18	187
Maritime Administration, U. S.....	5.13, 5.14	181, 187
Mark, Plimsoll.....	5.53 <i>m</i>	234
Marking:		
Beach.....	5.39	222
Cargo.....	2.7 <i>b</i> , 2.11, 4.17, 7.17, 7.18	33, 35, 149, 285, 289
Color.....	7.18	289
Draft.....	5.53 <i>e</i>	234
Hydrographic.....	5.38, 5.57	222, 238
Rail car.....	4.17	149
Vehicle.....	3.13 <i>b</i> , 3.16	62, 73
Materials-handling equipment.....	3.1, 3.47, 4.16 <i>g</i> , 5.26 <i>b</i> , 5.32 <i>c</i> , 7.6, 7.15	42, 118, 148, 203, 207, 273, 285
Mathematical tables.....	7.58-7.63	357
Mat, chespalang.....	3.46	118
Mauler missile.....	3.33, 7.5	92, 270
Mean, aerodynamic.....	2.9	34
Mean draft, vessel.....	5.21	197
Measurement ton.....	5.54 <i>l</i>	236
Medical:		
Equipment supply.....	3.16, 7.4, 7.54, 7.55	73, 262, 351
Treatment.....	7.23	295
Units.....	4.19 <i>a</i> , 5.2, 7.18, 7.23-7.26	155, 173, 289, 295
Message (<i>see also</i> Communication; Signal).....	7.20, 7.21	291
Meter, conversion.....	7.47 <i>a</i> , 7.53	339, 350
METO horsepower.....	2.2 <i>c</i>	5
Midship section.....	5.53 <i>n</i>	234
Mile, conversion.....	7.47 <i>a</i>	339
Military loading, vessel.....	5.35 <i>d</i>	219
Military police.....	5.2	173
Millimeter, conversion.....	7.60	359
MILSTAMP.....	7.17	285
Mine.....	3.8 <i>d</i> , 5.19 <i>a</i> , 7.32 <i>b</i>	54, 195, 325
Missile.....	3.1, 3.33, 5.19 <i>a</i> , 7.5	42, 92, 195, 270
Mohawk airplane.....	2.3	22
Mojave helicopter.....	2.3	22
Moment, aircraft.....	2.9 <i>f</i> , 2.10	34, 35
Monorail, vessel.....	5.26 <i>b</i>	203
Moon.....	7.65	363
Morse code (<i>see also</i> Communication; Signal).....	7.20 <i>a</i>	291
Motor-park checklist.....	3.41	111

	Paragraph	Page
Motor transport (<i>see also</i> Highway; Road; Vehicle)-----	3.1, 3.4-3.6, 3.16, 3.17, 3.20, 3.35, 5.2, 7.1, 7.11, 7.70- 7.72	42, 51, 73, 74, 79, 95, 173, 261, 281, 373
Movements-----	2.7, 2.11, 3.1, 3.4- 3.6, 3.16, 3.20, 3.35, 4.7, 7.1	33, 35, 42, 51, 52, 73, 79, 95, 132, 261
Mud-----	3.40, 3.46	110, 118
Mule. (<i>See</i> Animal.)-----	4.4, 7.2b	130, 261
Munitions. (<i>See</i> Ammunition; Weapons.)-----		
91A gasoline-----	3.48	120
N vessel-----	5.13b, 5.14	182, 187
Nails-----	4.14, 4.16, 7.35	141, 147, 328
National Security Agency, shipment marking-----	7.18d	290
NATO:		
Vehicle marking-----	3.16	73
Road signs-----	3.15	66
Natural trigonometric function-----	7.62	361
Nautical:		
Distance-----	5.56	237
Twilight-----	7.64a, 7.65f	363, 368
Navigation-----	5.32c, 5.38, 7.69	207, 222, 370
Navy, U. S.-----	2.5, 2.6, 2.16, 5.12, 5.19, 7.18b	28, 31, 37, 180, 195, 290
Nerve gas. (<i>See</i> Chemical Attack.)-----		
Net:		
Cargo-----	2.16, 3.31, 5.26b	37, 90, 203
Road-----	3.7, 3.38	52, 96
Net tonnage-----	5.54m	236
Net trainload-----	4.21b	158
Night hand signals-----	3.17b	74
Nike-Ajax missile-----	3.33, 7.5	92, 270
Nike-Hercules missile-----	3.33, 7.5	92, 270
Nike-Zeus missile-----	7.5	270
Nonpropelled vessel (<i>see also</i> Barge)-----	5.8, 5.14, 5.19c, 5.20	178, 187, 196, 197
North Atlantic Treaty Organization. (<i>See</i> NATO.)-----		
North, horizontal direction-----	7.69c	370
Nuclear attack-----	3.8, 7.24	53, 297
Numbers, functions of-----	7.59	358
Nun buoy-----	5.57b	238
0-1E airplane-----	2.3	22
Observation airplane-----	2.20b	38
Obstruction, route-----	3.11	59
Oceangoing tug-----	5.5, 5.14	175, 187
OH-13 helicopter-----	2.3	22
OH-23 helicopter-----	2.3	22
Oil (<i>see also</i> POL)-----	3.2, 3.48, 7.27-7.32, 7.49	44, 120, 311, 347
On-equipment material-----	3.3	51
Open storage-----	5.27a, 7.38a	205, 329
Open terminal-----	5.25c	201
Open waterway-----	5.32c	207
Open-top cars (<i>see also</i> Boxcar)-----	4.14	141
Operating distance:		
Aircraft-----	2.2d	7
Vehicle-----	3.2	44
Vessel-----	5.9-5.11	179
Operation order-----	3.23, 6.1, 6.2	84, 242
Operations:		
Aircraft-----	2.7-2.22	33
Cold weather-----	7.9-7.11	279

	Paragraph	Page
Operations (Cont)		
Decontamination.....	7.24-7.26	297
Motor transport.....	3.1, 3.4, 3.39	42, 51, 109
Rail.....	4.6-4.20	131
Supply.....	3.35	95
Water transport.....	5.1, 5.22-5.38	170, 199
Opposed engine.....	2.2c	5
Order:		
Administrative.....	6.3, 6.4	244, 246
Division embarkation.....	6.7	253
Operation.....	3.23, 6.1, 6.2	84, 242
Troop movement.....	4.20b	157
Ordnance (see also Ammunition):		
Equipment and supply.....	7.4, 7.54, 7.55	262, 351
Units.....	5.2, 7.18, 7.39	173, 289, 329
Organizational maintenance.....	3.1, 3.39, 4.1, 4.24- 4.26, 5.1	42, 109, 124, 165, 170
Orientation, map.....	7.69a	370
Other (M72).....	7.9a	279
Otter airplane.....	2.3	22
Ounce, conversion.....	7.47f	341
OV-1A airplane.....	2.3	22
Overhead clearance.....	4.10, 4.12	133, 138
Overpass.....	3.10	55
Oversea address marking.....	7.17c	289
Oxidizer, missile fuel.....	7.5	270
Oxygen.....	2.2b, 7.5	4, 270
P vessel.....	5.13b, 5.14	182, 187
Pacific Coast rivers.....	5.34b	210
Pack animal.....	4.4, 7.2	130, 261
Packet aircraft.....	2.5, 2.6	28, 31
Packing, cloverleaf.....	4.17	149
Packaging.....	7.14	285
Pail, grease (see also POL).....	7.29, 7.32c	323, 327
Pallet.....	3.31, 3.47, 5.26b, 7.14-7.16	90, 118, 203, 285
Panama Canal tonnage.....	5.54a	235
Parachute.....	2.18, 2.20b	38
Paratroops.....	2.5	28
Parallelogram, measurement.....	7.58	357
Party:		
Charter.....	5.55c	236
Shore.....	5.38, 5.39a	222
Passenger transport (see also Troop movement):		
Air.....	2.2b, 2.5a, 2.7c, 2.21b, 7.70-7.72	4, 28, 34, 38, 373
Motor.....	3.2, 3.40, 7.9c	44, 110, 280
Rail.....	4.5, 4.8d, 4.19	131, 132, 155
Water.....	5.4, 5.13, 5.14	174, 181, 187
Patrol vessel.....	5.19	195
Paulin. (See Tent.)		
Perpendicular:		
After.....	5.53a	234
Forward.....	5.53g	234
Pershing missile.....	3.33, 7.5	92, 270
Personnel carrier.....	3.2, 7.71	44, 375
Petroleum. (See POL.)		
Phonetic alphabet.....	7.20	291
Picket boat.....	5.4	174
Pier (see also Wharf).....	5.8, 5.20, 5.25c	178, 197, 201
Pipe.....	7.27	311
Pipeline.....	7.1, 7.27, 7.30	261, 311, 323

	Paragraph	Page
Piston. (<i>See</i> Weapons.)		
Pitch, propeller blade.....	2.2c	5
Placard, railcar.....	4.17	149
Plan:		
Division embarkation.....	6.7	253
Stowage.....	5.26b	203
Traffic circulation.....	3.7	52
Transportation.....	6.11, 6.12	257, 258
Planning (<i>see also</i> Estimate).....	7.37	329
Air.....	2.2	4
Motor.....	3.5, 3.38	51, 96
Rail.....	4.6	131
Terminal and water.....	5.22-5.24, 5.26, 5.28, 5.31, 5.32, 5.35, 5.37c	199, 202, 205, 206, 207, 218, 221
Plant poisoning.....	7.23k	296
Platform clearance, rail.....	4.10, 4.12	133, 138
Plimsoll mark.....	5.53m	234
Poisoning:		
Bite.....	7.23f	296
Carbon-monoxide.....	7.23i	296
Plant.....	7.23k	296
POL:		
Container.....	7.29, 7.32c	323, 327
Conversion.....	7.49	347
Pipeline.....	7.27	311
Requirement.....	2.2-2.4, 2.9b, i, 3.1, 3.48, 4.6n, 4.21- 4.26, 4.28, 4.33, 5.3-5.7, 5.10, 5.11	4, 34, 42, 120, 131, 158, 167, 168, 173, 179, 180
Shipping tank.....	7.32c	327
Stowage.....	7.54b	351
Supply.....	7.31	324
Temperature.....	7.28f	323
Transport.....	7.30	323
Rail.....	4.3, 4.4, 4.17, 7.30	127, 130, 149, 323
Vehicle.....	3.2, 3.30, 3.34	44, 89, 95
Vessel.....	5.7, 5.8, 5.13b, 5.14, 5.15, 5.19b, 5.20, 5.25b	176, 178, 182, 187, 196, 197, 200
Transporter.....	7.9b, 7.30	280, 323
Polar coordinates.....	7.69e	372
Pole:		
Gin.....	7.45	336
Telephone.....	7.8	278
Polygon, measurement.....	7.58	357
Port designator.....	7.17a	285
Pound, conversion.....	7.47f, 7.53	341, 350
Power:		
Conversion.....	7.47e	340
Electricity.....	4.1, 7.47	124, 340
Locomotives.....	4.6r	131
Powerplant, aircraft.....	2.2c	5
Precipitation (<i>see also</i> Weather).....	7.12	281
Pressure:		
Conversion.....	7.47j	342
Ground.....	3.2	44
Tire.....	3.40	110
Prime mover.....	3.13, 5.26b	62, 203
Profile diagram:		
Beach.....	5.37c	221
Loading.....	5.26b	203

	Paragraph	Page
Priority:		
Air	2.7a	33
Cargo	2.11, 2.12	35
Vehicle	3.16	73
Prism, measurement	7.58	357
Project A ADM missile	7.5	270
Project code	7.17a	285
Proepllant (<i>see also</i> POL)	7.5, 7.32b	270, 325
Propeller:		
Aircraft	2.2c	5
Vessel	5.13c	182
Provider aircraft	2.5, 2.6	28, 31
Pulley	2.5, 2.6	28, 31
Pullman. (<i>See</i> Sleeping car.)		
Pump	7.6, 7.9d, 7.27c	273, 280, 311
Purification of water	7.24-7.26, 7.42	297, 334
Pyramid, measurement	7.58	357
Q boat	5.4, 5.20	174, 197
Quadrilateral, measurement	7.58	357
Quart, conversion	7.47c	340
Quartermaster:		
Equipment and supply	7.4, 7.18, 7.54, 7.55	262, 289, 351
Units	5.2	173
Quay	5.25d	202
R vessel	5.13b	182
R4D aircraft	2.5, 2.6, 2.16	28, 31, 37
R4Q-2 aircraft	2.5, 2.6	28, 31
R5D-5 aircraft	2.5, 2.6, 2.16	28, 31, 37
R6D aircraft	2.5, 2.6, 2.16	28, 31, 37
Radial engine	2.2c	5
Radiation	7.24b	297
Radio	7.4, 7.20, 7.22	262, 291, 294
Radiological decontamination	7.24	297
Radius, aircraft	2.2d	7
Railroad:		
Bridge	4.13	138
Car (<i>see also</i> Boxcar)	4.3-4.5, 4.9, 4.16e, 4.17, 7.4, 7.30, 7.71	127, 133, 147, 149, 262, 323, 375
Construction	4.21, 4.23	158, 164
Engine. (<i>See</i> Locomotive.)		
Equipment	4.3, 4.22d	127, 162
Facilities	4.6g, 4.8e, 4.21, 4.24- 4.26	131, 132, 158, 165
Maintenance	4.24-4.27	165
Operations	4.6, 4.7	131, 132
Planning	4.19	155
Rehabilitation	4.8e, 4.21, 4.23b	132, 158, 165
Supply	4.33, 4.35	168, 169
Tonnage	4.8, 4.21, 7.1	132, 158, 261
Units	4.1, 7.39, 7.70-7.72	124, 329, 373
Rails	4.6e, 4.9a, 4.11, 4.12 4.21, 4.27	131, 133, 138, 158, 167
Ramp:		
Aircraft	2.6	31
Vessel	5.26b	203
Range:		
Aircraft	2.2-2.5	4
Vehicle	3.2	44
Vessel	5.3-5.5, 5.7, 5.9-5.12, 5.15	173, 176, 179, 187
Range marking	5.38c	222
Rating, Cooper's E	4.13	138

	Paragraph	Page
Rations (<i>see also</i> Supply).....	3.36, 5.35d, 7.31, 7.32, 7.54b, 7.56b	95, 219, 324, 351, 354
Raven helicopter.....	2.3	22
Reception capacity, terminal.....	5.23, 5.24, 5.33	199, 200, 209
Reciprocating engine.....	2.2c	5
Reconnaissance:		
Air.....	2.20a	38
Beach.....	5.37c	221
Rail.....	4.8i	132
Road and route.....	3.5, 3.10, 3.11	51, 55, 59
Reconnaissance sled.....	7.9b	280
Records and reports:		
Air.....	2.7, 2.8j	33, 34
Motor.....	3.4b, 3.5j, 3.10, 3.25, 3.26, 3.41	51, 52, 55, 86, 111
Rail.....	4.7, 4.8e, f, 4.18b, 4.24, 4.25, 4.33, 4.35	132, 153, 165, 168, 169
Terminal and water transport.....	5.37c	221
Recovery, vehicle.....	3.44, 3.45	116
Rectangle, measurement.....	7.28, 7.58	313, 357
Redeye missile.....	7.5	270
Redstone missile.....	3.33, 7.5	92, 270
Reference datum line, aircraft.....	2.9c, 2.10	34, 35
Refrigerated cargo:		
Rail.....	4.3e, 4.4, 4.16f	129, 130, 148
Vehicle.....	3.34b	95
Vessel.....	5.3, 5.13, 5.17, 5.20	173, 181, 188, 197
Refueling time, aircraft.....	2.20	38
Register ton.....	5.54h	236
Relay yard, rail.....	4.21c	161
Release points.....	3.22b	84
Release supply movements.....	3.4b	51
Repair parts. (<i>See</i> Supply.)		
Repair shop, floating.....	5.8, 5.20	178, 197
Replacement factor.....	7.37c	329
Reports. (<i>See</i> Records and reports.)		
Request, highway scheduling.....	3.28	87
Required delivery date.....	7.17a	285
Requisition (<i>see also</i> Supply).....	2.16, 4.33, 7.17	37, 168, 285
Resistance, curve.....	4.28	167
Respiration, artificial.....	7.23	295
Restraint. (<i>See</i> Lashing.)		
Return load.....	3.4a	51
Revenue ton.....	5.54k	236
Rifle. (<i>See</i> Weapons.)		
Rig (<i>see also</i> Boom; Hoist).....	5.26b, 5.49	203, 230
Right-of-way, rail.....	4.24, 4.27	165, 167
Rip tracks.....	4.24-4.26	165
Rivers.....	5.31, 5.32, 5.34	206, 207, 209
Road:		
Capacity.....	3.38	96
Chespaling.....	3.46	118
Classification.....	3.11b	60
Clearance.....	3.26	86
Decontamination.....	7.26b	307
Graph.....	3.20	79
Log.....	3.23	84
Net.....	3.7, 3.38	52, 96
Reconnaissance.....	3.10	55
Sign.....	3.14, 3.15	62, 66
Table.....	3.20, 3.22, 3.27	79, 82, 87

	Paragraph	Page
Rocket.....	3.33, 7.5	92, 270
Launcher.....	3.8e, 7.4, 7.7	34, 262, 276
Trailer.....	3.33c	93
Rod, conversion.....	7.47a	339
Rods and bolts.....	7.34	328
Rolling liquid transporter (<i>see also</i> POL).....	7.30	323
Rolling resistance, rail.....	4.32	168
Rolling stock (<i>see also</i> Boxcar).....	4.8b, 4.22d, 4.24-4.26	132, 162, 165
Roll-on/roll-off vessel.....	5.12, 5.26b	180, 203
Root, cube and square.....	7.58	357
Rope (<i>see also</i> Line, Cable):		
Manila.....	2.14, 2.15, 5.26b,	36, 37, 203,
5.40-5.42, 5.46-5.49		225, 227
Wire.....	5.43-5.46, 5.49	227, 230
Rotary-wing aircraft. (<i>See</i> Helicopter.)		
Rotors, helicopter.....	2.2c	5
Rough-terrain forklift.....	7.6b	274
Route:		
Classification.....	3.11a	59
Obstruction.....	3.11c	62
Reconnaissance.....	3.10b	55
Type.....	3.11a	59
S vessel.....	5.13b	182
SS-10 Missile.....	3.33, 7.5	92, 270
SS-11 Missile.....	3.33, 7.5	92, 270
ST tug.....	5.5, 5.20	170, 197
STI vessel.....	5.20	197
Sabotage.....	4.23	64
Safe working load for (<i>see also</i> Tensile strength):		
Chains.....	5.45	227
Hooks.....	5.47	229
Slings.....	5.46	227
Safety.....	2.15a, 3.45b, 4.11,	37, 117, 133,
4.15, 4.16b, 5.40		145, 147, 225,
5.41, 5.44, 5.49, 7.12		227, 230, 281
Sagging, vessel.....	5.53o	234
Sailing distances.....	5.56	237
Salt water.....	7.24	297
Sand.....	3.40, 3.46	110, 118
Sanitation.....	4.20b, 7.40, 7.42	157, 329, 334
Scheduling:		
Rail.....	4.7b, 4.8c	132
Highway.....	3.28	87
Sea-island terminal.....	5.8	178
Sedan. (<i>See</i> Automobile.)		
Sedimentation, water.....	7.42f	336
Selective loading, vessel.....	5.26b, 5.35d	203, 219
Semaphore signal.....	7.20a	291
Seminole airplane.....	2.3	22
Semitrailer. (<i>See</i> Trailer.).....	7.4	262
Sergeant missile.....	3.33, 7.5	92, 270
Serial, march.....	3.16, 3.20, 3.22	73, 79, 82
Service-color marking.....	7.18	289
Set, radio.....	7.4, 7.22	262, 294
Shawnee helicopter.....	2.3	22
Shears.....	7.44	336
Sheaves.....	5.48, 5.49	229, 230
Shell. (<i>See</i> Ammunition.)		
Shillelagh missile.....	7.5	270
Ship. (<i>See</i> Barge; Landing craft; Lighter; Tug; Vessel.)		
Ship ton.....	5.54l	236

	Paragraph	Page
Shipping (<i>see also</i> Cargo; Loading):		
Address.....	7.17	285
Box, reuseable, metal.....	3.1, 5.26b, 7.4, 7.14, 7.18	42, 203, 262, 285, 289
Symbols.....	7.17	285
Terms.....	5.55	236
Ship-repair wharf.....	5.25c	201
Shock, first aid.....	7.23	295
Shop floorspace.....	7.39	329
Shore party.....	5.38, 5.39a	222
Shoring.....	5.26b	203
Short ton.....	5.54n	236
Siding, rail.....	4.18c, 4.21	155, 158
Signal (<i>see also</i> Communications; Markings):		
Equipment and supply.....	7.4, 7.18, 7.19, 7.22, 7.54, 7.55	262, 289, 290, 294, 351
Ground-air.....	7.21	291
Motor.....	3.17	74
Rail.....	4.6r, 4.21, 4.23, 4.24	131, 158, 164, 165
Storm warning.....	5.58	239
Units.....	5.2	173
Sign:		
Bridge.....	3.12	62
Road.....	3.14, 3.15	62, 66
Simple tackle.....	5.49	230
Sioux helicopter.....	2.3	22
Sisal rope (<i>see also</i> Manila rope).....	5.41	225
Skis.....	7.9, 7.10	279, 281
Skymaster aircraft.....	2.5, 2.6	28, 31
Skytrain aircraft.....	2.5, 2.6	28, 31
Sled.....	7.4, 7.9b, 7.71	262, 280, 375
Dog.....	7.2a	261
Pallet.....	7.16	285
Train.....	7.9	279
Sleeping car.....	4.5, 4.19a	131, 155
Slice, division.....	7.1, 7.37d	261, 329
Sling.....	5.44, 5.46	227
Slope percentage.....	7.68	370
Slurry.....	7.24-7.26	297
Snakebite, first aid.....	7.23f	296
Snow operations (<i>see also</i> Arctic data; Weather).....	3.35, 3.40, 3.46, 7.2a, 7.9, 7.10, 7.12	95, 110, 118, 261, 279, 281
Solar darkness.....	7.65	363
Solid, measurement.....	7.58	357
Space charter.....	5.55l	236
Spar buoy.....	5.57b	238
Specialized loading, vessel.....	5.26b	203
Speed:		
Aircraft.....	2.2-2.5, 2.27	4, 41
Conversion.....	7.47f, 7.51	341, 348
Floating craft.....	5.3-5.5, 5.9-5.11, 5.15, 5.32b, 5.36	173, 179, 187, 207, 220
Helicopter.....	2.27	41
Train.....	4.19a, 4.22h	155, 164
Speedometer multiplier.....	3.21c	81
Sphere, measurement.....	7.28e, 7.58	322, 357
Splint.....	7.23c	295
Spur-gear hoist.....	5.51	233
Square, area.....	7.58	357
Square foot, conversion.....	7.47h	342
Square mile, conversion.....	7.47b	339
Square root.....	7.59	358
Stack height (<i>see also</i> Stowage).....	5.27, 7.38b	205, 329

	Paragraph	Page
Staging area company	5.1, 5.2, 7.70-7.72	170, 173, 373
Standard atmosphere	2.2b	4
Standing operating procedure:		
Air movement	2.7	33
Air transport service	2.8	34
Major command	6.5	248
Major transport	3.4, 3.5, 3.8, 3.26	51, 53, 86
Rail	4.7, 4.8	132
Unit	6.6, 7.24c	250, 298
Star	7.69c	370
Start point	3.22	82
State highway limitations	3.50	122
Station:		
Points, aircraft	2.2d, 2.9d, 2.10	7, 34, 35
Wagon	3.2	44
Station, rail	4.1, 4.20b, 4.21	124, 157, 158
Stays	5.43	227
Steam:		
Locomotive	4.2, 4.3, 4.24-4.26	126, 127, 165
Pressure	4.24-4.26	165
Steel:		
Chains	5.45	227
Tubing	7.27	311
Stevedore:		
Pallet	3.31	90
Ton	5.54l	236
Stiff ship	5.53p	234
Still, water purification	7.42a	334
Stock car, rail	4.4, 7.4	130, 262
Stock (see also Supply)	4.28, 4.33, 4.35	167, 168, 169
Stopping distance, vehicle	3.42	113
Storage	5.27, 7.38	238, 329
Storage batteries	7.13	284
Storm	5.58, 5.59	239, 241
Stowage (see also Loading)	3.2, 5.26, 5.35	44, 202, 218
Factors	5.52d, 5.53r, 7.7, 7.32, 7.54, 7.55	233, 234, 276, 324, 351
Plan	5.26b	203
Terms	5.52	233
Straddle truck	7.6f	274
Stratofreighter aircraft	2.5, 2.6	28, 31
Stringer, bridge	4.13	138
Strip map	3.23	84
Subsurface burst, nuclear	7.24a	297
Submarine	5.19a	195
Suez Canal tonnage	5.54a	235
Sun	7.64a, 7.65	363
Super Constellation aircraft	2.5, 2.6	28, 31
Super Star Constellation aircraft	2.5, 2.6	28, 31
Supercharged engine	2.2c	5
Supply	7.17, 7.55, 7.70	285, 351, 373
Aviation	2.1, 2.7b, 2.16, 7.31, 7.32, 7.54	3, 33, 37, 324, 351
Motor	3.4b, 3.5g, 3.35-3.37, 4.9	51, 95, 133
Rail	4.1, 4.8e, 4.33-4.35	124, 132, 168
Vessel	5.3	173
Surface:		
Burst, nuclear	7.24a	297
Measure	7.47b, 7.58	339, 357
Surface, road	3.38	96
Swamp	3.46	118
Swinging boom	5.26b	203
Switchboard	7.4	262

	Paragraph	Page
Switch engine.....	4.22 <i>f, g</i>	163, 164
Symbol (<i>see also</i> Abbreviations: Code).....	App. III	397
Obstruction.....	3.11 <i>c</i>	62
Shipping.....	7.17	285
T boat.....	5.4, 5.20	174, 197
T tanker.....	5.13 <i>b</i> , 5.14	182, 187
T4 ADM missile.....	7.5	270
TADM missile.....	7.5	270
T-AK vessel.....	5.12	180
Tables, mathematical.....	7.58-7.63	357
Tables of Allowances.....	4.30	168
Tables of Organization and Equipment.....	2.1, 3.1, 3.3, 3.33, 3.41, 4.1, 5.1, 5.2, 5.22 <i>a</i> , 5.29, 5.30, 7.70-7.22	3, 42, 51, 92, 111, 124, 170, 173, 199, 205, 206, 373
Tackle.....	5.49	230
Tactical:		
Carrier units.....	3.1, 7.70-7.72	42, 373
Vehicle marking.....	3.16	73
Takeoff, aircraft.....	2.2, 2.27	4, 41
Tank, capacity.....	7.28	313
Tank, tracked.....	3.2, 3.30, 4.14, 4.19 <i>a</i> , 5.14, 5.26 <i>b</i> , 7.10	44, 89, 141, 187, 203, 281
Tanker (<i>see also</i> POL):		
Motor.....	3.2, 3.30, 3.40	44, 89, 110
Rail.....	4.3, 4.4, 4.17, 7.30	127, 130, 149, 323
Vessel.....	5.13 <i>b</i> , 5.14, 5.15, 5.19 <i>b</i> , 5.20, 5.25 <i>b</i>	182, 187, 196, 197, 200
Target tonnage.....	5.22, 5.24, 5.27 <i>b</i>	199, 200, 205
Tarpaulin. (<i>See</i> Tent.)		
Task force, amphibious.....	5.35 <i>c</i>	219
Team (TOE):		
Air.....	2.1	3
Motor.....	3.1	42
Rail.....	4.1	124
Water.....	5.1, 5.30	170, 206
Telegraphic procedures.....	7.20 <i>a</i>	291
Telephone:		
Pole.....	7.8	278
Set.....	7.4	262
Telltale, rail.....	4.10, 4.12	133, 138
Temperature (<i>see also</i> Weather).....	2.2 <i>b</i> , 4.22 <i>a</i> , 7.12, 7.13, 7.28 <i>f</i> , 7.47 <i>h</i> , 7.53	4, 162, 281, 284, 323, 342, 350
Tender ship.....	5.53 <i>g</i>	234
Tensile strength (<i>see also</i> Safe working load):		
Annealed wire.....	7.33	328
Bands.....	7.36	326
Lashing.....	2.13-2.15	35
Rods and bolts.....	7.34	328
Rope.....	5.41, 5.43	225, 227
Tent.....	4.9, 7.4, 7.41	133, 262, 332
Terminal:		
Air.....	2.7 <i>a, b</i> , 2.21, 7.17	33, 38, 285
Rail.....	4.8 <i>b</i> , 4.18 <i>b</i> , 4.21 <i>c</i> , 4.22 <i>c</i>	132, 153, 161, 162
Truck.....	3.9	55
Water.....	4.21, 5.1, 5.2, 5.8, 5.22, 5.24, 5.25, 5.28-5.34, 5.37, 7.1, 7.6, 7.16	158, 170, 173, 178, 199, 200, 205, 221, 261, 273, 285
Terminal service company.....	5.1, 5.2, 5.22 <i>a</i> , 5.28, 5.29 <i>f</i> , 7.70-7.72	170, 173, 199, 205, 206, 373

	Paragraph	Page
T-head pier	5.25c	201
Thrust:		
Lashing	2.14	36
Missile	7.5	270
Throughout capacity, terminal	5.23, 5.24, 5.33	199, 200, 209
Tide	5.25c, 7.65	201, 363
Tiedown, aircraft. (See Lashing.)		
Ties, railroad	4.6g, 4.9b, 4.21	131, 133, 158
Time:		
March	3.18c	74
Rail	4.22d	162
Supply	3.36	95
Unloading	2.20, 2.23c, 5.26b, 5.35d	38, 39, 203, 219
Time-distance graph	3.18e	78
Time-zone chart	7.64b	363
Tires	3.2, 3.40, 7.6	44, 110, 373
Toll bridge	3.10	55
Ton:		
Conversion	7.47	339
Displacement	5.54d	236
Freight	5.54l	236
Gross	5.54h	236
Long	5.54j	236
Manifest	5.54k	236
Measurement	5.54l	236
POL	7.48	346
Register	5.54h	236
Revenue	5.54k	236
Ship	5.54l	236
Short	5.54n	236
Stevedore	5.54l	236
Vessel	5.54h	236
Tonnage:		
Aircraft payload	2.2-2.4	4
Anticipated	5.24	200
Beach	7.1	261
Deadweight	5.21	197
Highway	3.2, 3.30, 3.38, 7.1	44, 89, 96, 261
Initial	5.24	200
Pipeline	7.1	261
Rail	4.21b, 7.1	158, 261
Requirements	7.1	261
Storage	5.27b, 5.36	205, 220
Target	5.22, 5.24, 5.27b	199, 200, 205
Terminal	5.22, 7.1	199, 261
Terms	5.54	235
Vessel	5.3, 5.4, 5.6-5.12, 5.15-5.17, 5.21, 7.1	173, 174, 175, 187, 197, 261
Tools	4.9, 7.4	133, 262
Tourniquet	7.23a	295
Towboat	5.5, 5.8, 5.13b, 5.14, 5.19c, 5.20, 5.32	175, 178, 182, 187, 196, 197, 207
Towed vehicles	3.13b, 3.44, 3.45, 3.50	62, 116, 122
Track, rail	4.1, 4.6b, m, 4.21- 4.24, 4.27, 4.29, 4.30	124, 131, 158, 167, 168
Tractive effort, locomotive	4.3, 4.21b	127, 158
Tractor	3.2, 3.50, 7.4, 7.6c, 7.9a, 7.10, 7.71	44, 122, 262, 274, 279, 281, 375
Traffic, highway (see also Highway capacity)	3.1, 3.4, 3.7, 3.10, 3.21, 3.27, 3.38c	42, 51, 52, 55, 81, 87, 97

	Paragraph	Page
Trailer.....	2.5b, 3.1, 3.2, 3.13b, 3.16a, 3.30, 3.33, 3.36, 3.37b, 3.40, 3.41, 3.48, 3.49, 5.18, 5.26b, 7.4, 7.6e, 7.30, 7.71	29, 42, 44, 62, 73, 89, 92, 95, 96, 110, 111, 120, 122, 190, 203, 262, 274, 323, 375
Train operating company.....	4.1, 7.70-7.72	124, 373
Train:		
Rail.....	4.1, 4.7, 4.8, 4.15, 4.18-4.21	124, 132, 145, 150
Sled.....	7.9	279
Transit shed.....	5.25c	201
Transport aircraft units.....	2.1, 7.20-7.72	3, 291
Transportation:		
Annex.....	6.4	246
Estimate.....	6.10	255
Intelligence.....	6.8, 6.9	254
Plan.....	6.11, 6.12	257, 258
Transportability.....	2.2f, 2.5b, 4.14, 5.11, 5.18, 7.2c, 7.70-7.72	10, 29, 141, 180, 190, 262, 373
Transporter:		
Cargo.....	3.31, 7.4, 7.14	90, 262, 285
Liquid (<i>see also</i> POL).....	7.9b, 7.30	280, 323
Missile.....	3.33c	93
Tank.....	3.2, 3.30, 5.14	44, 89, 187
Trapazoid, measurement.....	7.58	357
Travel warrant.....	4.7c	132
Treadway, aircraft.....	2.5, 2.6	28, 31
Triangle, measurement.....	7.58, 7.61	357, 360
Trigonometry.....	7.61, 7.62	360, 361
Troop movement.....	2.2-2.5, 2.7a, c, 2.9g, 2.20, 4.4, 4.5, 4.7c, 4.8e, 4.19, 4.20, 5.9, 5.10, 5.12	4, 33, 34, 38, 130, 131, 132, 155, 157, 179, 180
Truck.....	2.5b, 3.1-3.3, 3.8c, 3.13, 3.29-3.37, 3.40, 3.46-3.49, 4.14, 5.18, 5.26b, 7.4, 7.10, 7.71	29, 42, 54, 62, 88, 110, 118, 141, 190, 203, 281, 375
Truck terminal.....	3.9	55
Truck units.....	3.1, 3.8a, 3.30, 3.33, 3.34, 5.2, 7.39, 7.70- 7.72	42, 53, 89, 92, 95, 173, 329, 373
True north.....	7.69c	370
Tubing.....	7.27d	311
Tugboat.....	5.5, 5.13b, 5.14, 5.19c, 5.20, 5.32, 7.4	175, 182, 187, 196, 197, 207, 262
Tunnel:		
Highway.....	3.10c	57
Rail.....	4.6l, 4.10, 4.12, 4.18b, 4.21b, 4.23, 4.27	131, 133, 138, 153, 158, 164, 167
Turbo-jet engine.....	2.2c	5
Turbo-prop engine.....	2.2c	5
Turbo-shaft engine.....	2.2c	5
Turnaround time:		
Vehicle.....	3.34	95
Vessel.....	5.32c, 5.36c	207, 221
Turnover factor, rail yard.....	4.21c	161
Twilight.....	7.64a, 7.65f	363, 368
U-1A airplane.....	2.3	22
U-6A airplane.....	2.3	22

	Paragraph	Page
U-8D airplane.....	2.3	22
UFD/ADM missile.....	7.5	270
UH-1A helicopter.....	2.3	22
UH-1B helicopter.....	2.3	22
UH-19D helicopter.....	2.3	22
Unconsciousness, first aid.....	7.23 <i>l</i>	296
Underpass.....	3.10	55
Unit:		
Equipment.....	7.6, 7.71	273, 375
Movement.....	3.34, 4.19 <i>b</i> , 5.35 <i>d</i> , 7.57, 7.70-7.72	95, 157, 219, 238, 373
SOP.....	6.6	250
Weight.....	7.57	357
Unitized cargo.....	3.31, 7.14	90, 285
Unloading:		
Aircraft.....	2.20, 2.23 <i>c</i>	38, 39
Vessel.....	5.26 <i>b</i> , 5.35 <i>d</i>	203, 219
Utility vessel.....	5.4	174
V vessel.....	5.13 <i>b</i> , 5.14	182, 187
V-C2. (<i>See</i> Victory ship.)		
Vehicles:		
Amphibious (<i>see also</i> Landing craft).....	4.14 <i>b</i> , 5.1, 5.11, 5.18, 5.20, 5.26 <i>b</i> , 5.35, 5.36, 5.39, 5.52 <i>b</i> , 7.4, 7.16	143, 170, 180, 190, 197, 203, 219, 220, 222, 233, 262, 285
Land (<i>see also</i> particular types of equipment).....	3.1-3.3, 3.6, 3.8 <i>c</i> , 3.13, 3.16, 3.29- 3.37, 3.39, 3.41, 3.42, 3.44-3.50, 4.4, 4.16, 4.19 <i>c</i> , 7.4, 7.10, 7.11, 7.13, 7.38-7.40, 7.71	42, 52, 54, 62, 73, 88, 109, 111, 113, 116, 130, 147, 157, 262, 281, 284, 329, 375
Vessel (<i>see also</i> particular types of craft):		
Anchorage.....	5.25, 5.29 <i>b</i>	200, 205
Availability.....	5.1, 5.32 <i>d</i> , 5.36	170, 208, 220
Berth.....	5.25	200
Capacity.....	5.3, 5.4, 5.6-5.12, 5.15-5.18, 5.21, 7.1, 7.4	173, 174, 175, 187, 197, 261, 262
Characteristics.....	5.3-5.20, 7.4	173, 262
Classification.....	5.3-5.15, 5.19, 5.20, 5.25 <i>b</i>	173, 195, 197, 200
Deadweight scale.....	5.21	197
Discharge rate.....	5.26	202
Draft.....	5.3-5.12, 5.15, 5.21, 5.25	173, 187, 197, 200
Factor.....	5.53 <i>r</i>	234
Terms.....	5.53	234
Ton.....	5.54 <i>h</i>	236
Tonnage.....	5.21	197
Victory ship.....	5.13-5.18, 5.21	181, 197
Visual flight rules.....	2.2 <i>b</i>	4
Volume, formulas.....	7.28, 7.58	313, 357
Wanigan.....	7.9	279
Warehouse:		
Crane.....	7.6 <i>d</i>	274
Pallet.....	3.31	90
Tractor.....	7.6 <i>c</i>	274
Trailer.....	7.6 <i>e</i>	274
Warning sign (<i>see also</i> Marking; Symbol).....	3.14-3.16, 4.10, 4.17, 5.58	62, 133, 149, 239
Warship.....	5.19 <i>a</i>	195

	Paragraph	Page
Water:		
Purification	7.24f, 7.42	303, 334
Requirements:		
Rail	4.3a, 4.21b, 4.23, 4.27	127, 158, 164, 167
Vehicle	3.37a	96
Supply	3.37, 7.40, 7.42c	96, 329, 334
Water terminal:		
Capacity	4.21b, 5.22, 5.24, 5.25, 5.28, 5.29, 5.31-5.34, 7.1	158, 199, 200, 205, 206, 261
Operations	5.1, 5.22-5.38	170, 199
Organization	5.1, 5.2, 5.26, 5.30, 5.37	170, 173, 202, 206, 221
Planning	5.22, 5.24, 5.25	199, 200
Units	5.1, 5.2, 5.30, 5.37, 7.70-7.72	170, 173, 206, 221, 373
Waterline, load	5.13, 5.53l	181, 334
Waterway, inland	5.7, 5.20, 5.30-5.34	176, 197, 206, 209
Watts, conversion	7.47e	340
Weapons (<i>see also</i> Ammunition)	2.5b, 3.8c, 3.33, 4.9a, 4.14, 7.4, 7.5, 7.7	29, 54, 92, 133, 141, 262, 270, 276
Weasel	7.9a	279
Weather (<i>see also</i> Arctic data, Snow operations)	2.2b, 3.8b, 3.35, 5.25c, 5.29g, 5.58, 5.59, 7.12, 7.64	4, 53, 95, 201, 206, 239, 241, 281, 363
Weight, conversion	7.47f, 7.54b	341, 351
Wharf (<i>see also</i> Pier)	5.1, 5.25, 5.29	170, 200, 205
Wheels, locomotive	4.2, 4.13	126, 138
Whistle buoy	5.57b	238
Whyte classification system	4.2	126
Wig-wag signal	7.20a	291
Winch	2.5, 2.6, 3.45	28, 31, 116
Wind	2.2b, 5.59	4, 241
Windchill factor	7.12	281
Windlass	7.43	336
Winter operations (<i>see also</i> Arctic data)	7.9-7.13	279
Wire (<i>see also</i> Rope)	4.9a, 4.14-4.16, 5.26b, 5.43, 5.44, 5.46e, 5.49, 7.33	133, 141, 203, 227, 229, 230, 328
Workload, terminal	5.22, 5.24	199, 200
Workshop, rail	4.24	165
Worm-gear hoist	5.51	233
Wound, first aid	7.23a	295
Wrecker	3.2, 3.30, 4.3g	44, 89, 130
WV2 aircraft	2.5, 2.6, 2.16	28, 31, 37
Y vessel	5.3, 5.20	173, 197
Yard, conversion	7.47a	339
Yard, rail	4.6p, 4.8e, 4.18b, 4.21c	131, 132, 153, 161
Yard-and-stay rig	5.26b	203
Yardmaster	4.18b	153
YC-121F aircraft	2.5, 2.6	28, 31

By Order of the Secretary of the Army:

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Chief of Staff.

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For explanation of abbreviations used, see AR 320-50.

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